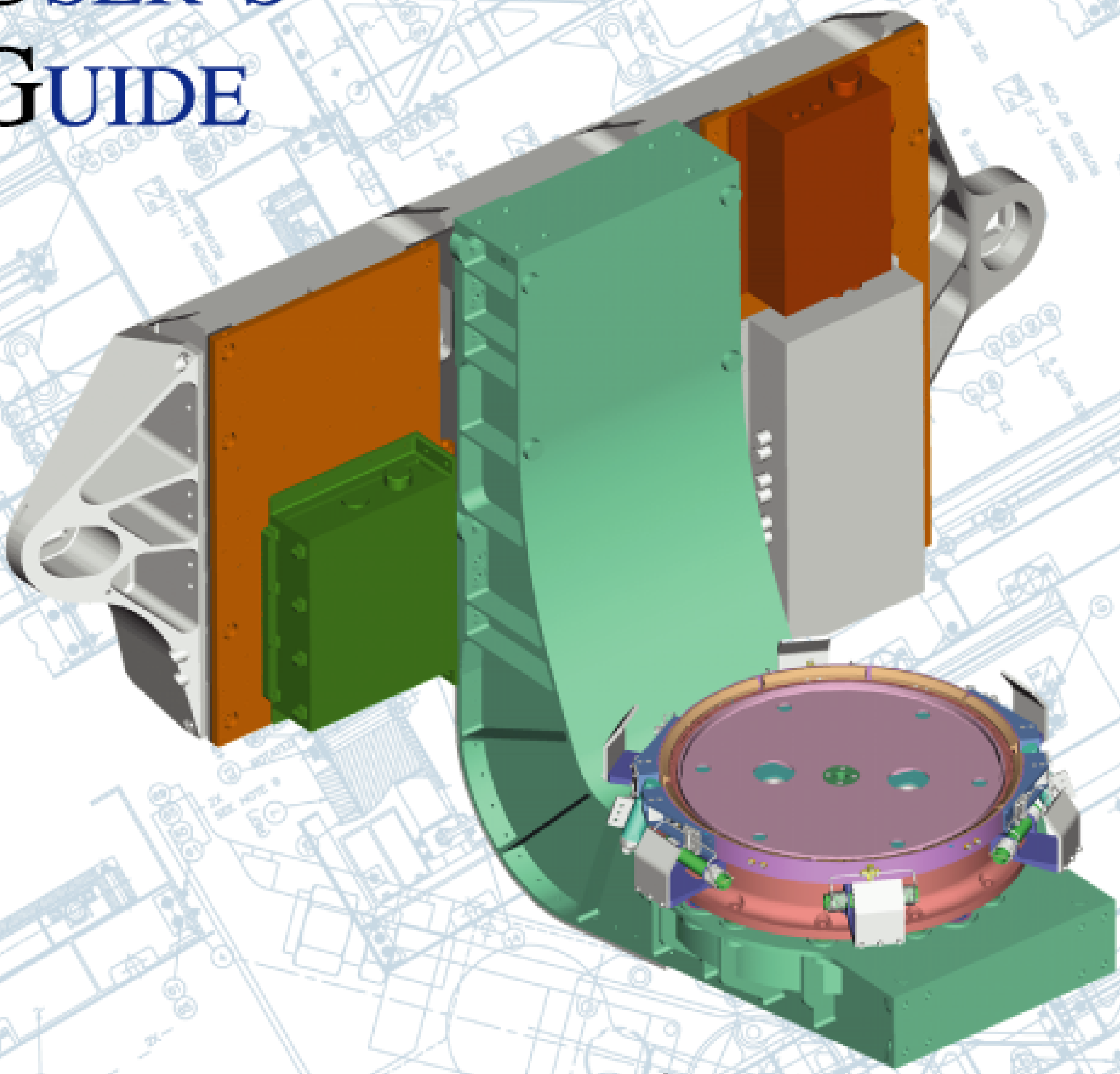
NASA Goddard Space Flight Center
Greenbelt, MD

SSPP-SPEC-040
Revision –
December 1999

SHELS User's Guide



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REVISIONS

REVISION	DESCRIPTION	DATE	APPROVAL
-	Baseline Release	11-24-99	G. Daelemans

1.0 INTRODUCTION

In 1984, the National Aeronautics Space Administration (NASA) Headquarters Office of Space Flight (OSF) established the Shuttle Small Payloads Projects Office (SSPPO) at Goddard Space Flight Center (GSFC) to develop and execute carrier systems for low-cost and quick reaction accommodations of secondary payloads on the NASA Space Transportation System (STS). These carrier systems range from the more complex, such as the Hitchhiker (HH) carrier system, to the self-contained Get Away Special (GAS) carrier system.

To more fully enable GSFC to meet NASA's strategic goals for science, technology, and education, the SSPPO has developed an enhanced ejection capability called the Shuttle Hitchhiker Experiment Launch System (SHELS). SHELS consists of a marman band clamp, push-plate ejection system mounted to a launch structure. SHELS may occupy either a single or double sidewall Adapter Beam Assembly (ABA) configuration.

1.1 Purpose

The purpose of this document is to identify the SHELS system specific interface requirements and accommodations and is intended as a more specific companion document to the HH CARS. The SHELS customer is not released from meeting all applicable requirements imposed by the HH CARS document.

This document defines and controls the design of mechanical, thermal and electrical interfaces between SHELS users and the SHELS system. It is intended to support SHELS system users in the design and development of their SHELS payload as it relates to the SHELS system.

1.2 Point Of Contact

The Shuttle Small Payloads Projects Office may be contacted as follows:

Shuttle Small Payloads Projects Office, Code 870.G
Goddard Space Flight Center
Greenbelt, MD 20771
(301) 286-8799

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E-MAIL:	sspp@sspp.gsfc.nasa.gov
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2.0 SHELS DESCRIPTION & CAPABILITIES

SHELS consists of a launch structure, ejection system, avionics and mission unique thermal shroud. The system is designed to accommodate a wide range of spacecraft and provide a cost effective and user friendly launch system with minimum integration. SHELS may accommodate up to a 400-pound satellite with a Center of Gravity (CG) no more than 24 inches above the ejection system separation plane. The satellite CG must be within 0.25 inches of the ejection system centerline. The allowable spacecraft envelopes are discussed in section 4. The ejection system may be designed for velocities ranging from 1 ft/sec to 4 ft/sec. SHELS is tested for a minimum spacecraft weight parameter of 150 pounds with a CG offset of 10.25 inches from the separation plane.

As an optional capability, the ejection system allows for the mounting of two low force umbilical connectors, which provide power and telemetry prior to ejection. The total power available to the spacecraft is 280W at 28V DC and is divided among four circuits; these circuits are rated at 2.5A maximum, each. The signal interface shall provide 1200 baud asynchronous command and telemetry, three analog 0-5V signal inputs, three 28V bi-level signals, and a Mission Elapsed Time (MET) minute pulse.

SHELS provides for heater power to the spacecraft in two ways: (1) via a direct umbilical connection (as described in the preceding sections); and (2), via a thermal shroud, which shall radiate heat to the spacecraft. Details of the SHELS thermal shroud mechanical design and thermal hardware (heaters, thermostats, and wiring) are mission unique; however, provisions have been made in the design of SHELS to accommodate a shroud both from a mechanical and heater power standpoint. Details of the thermal shroud design shall be worked out once spacecraft envelopes and thermal requirements are identified. The carrier system has been designed such that 280W (@28VDC) may be used as heater power, thermostatically controlled and applied to the thermal shroud, which would radiate heat to the satellite.

Figure 2-1 is a 3D view of SHELS with major components labeled. The following is a brief description of each component.

- Adapter Beam Assembly (ABA) - The adapter beam is a side-mounted interface plate between the Orbiter sidewall and a Hitchhiker payload. Specifically mounted to the beam for a SHELS payload are two electronic mounting plates and the launch structure.
- Launch Structure Assembly - The launch structure is a premium quality, aerospace, structural casting. The structure attaches directly to an adapter beam. The ejection system assembly mounts to the casting.
- Ejection System Assembly - The ejection system assembly consists of an ejection base, a marman band, and a spring/push plate assembly. The bottom of the ejection base attaches to the launch structure and the satellite rests on top of the ejection base. The satellite is held in place via a marman clamp, which releases when two separation bolts are simultaneously cut using a pyrotechnic charge. After the separation bolts are cut, a centrally mounted spring drives a push plate against the bottom surface of the payload, launching it away from the orbiter.
- Electronics Mounting Plates - Two electronic mounting plates are used on SHELS. Each plate attaches directly

to the adapter beam. The plates provide attachment points to mount the HESE, HRIU, MPIB, and cable brackets.

- Multipurpose Interface Box (MPIB) - The Multipurpose Interface Box, (MPIB), provides the power and Standard Switch Panel (SSP) interface to the orbiter. It is used for fusing and distributing the orbiter power, power switching the HRIU, the HESE, and the shroud heaters, as well as housing circuit boards associated with the power distribution, shroud heater telemetry, and satellite isolation electronics.
- Hitchhiker Ejection System Electronics (HESE) - The Hitchhiker Ejection System Electronics (HESE) box provides the required number of safety inhibits and controls to prevent inadvertent satellite deployment.
- Hitchhiker Remote Interface Unit (HRIU) - The Hitchhiker Remote Interface Unit, (HRIU), provides a non-hazardous command and telemetry interface between the SHELS and a PGSC located in the crew compartment.
- Thermal Shroud - The specific design of the thermal shroud will vary from mission to mission and be driven by particular thermal requirements of the satellite. The maximum heater output is 280W.

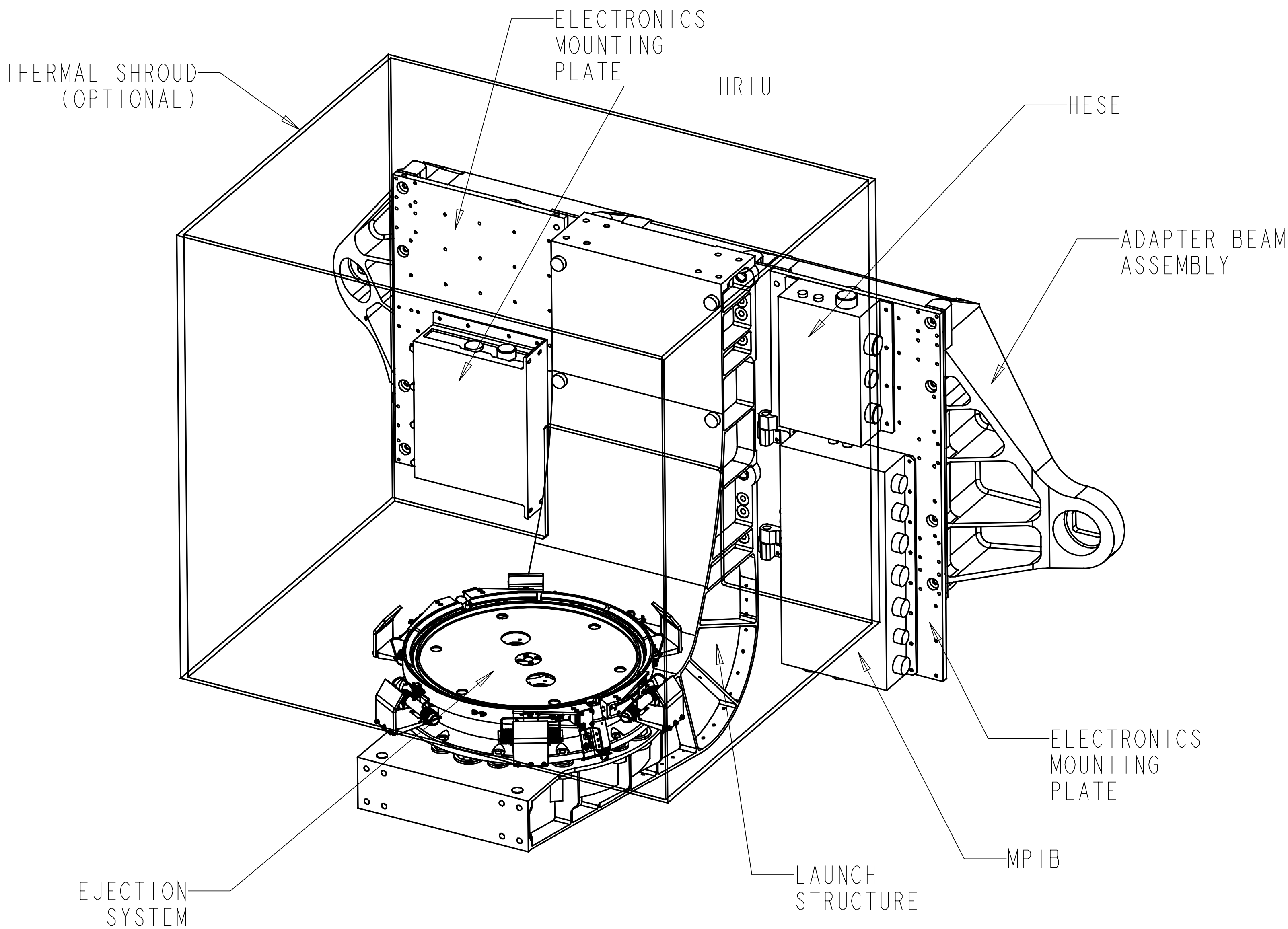


Figure 2-1: SHELS Single Beam Configuration

3.0 CUSTOMER DOCUMENTATION

3.1 SHELS Customer Required Documents

3.1.1 Customer Payload Requirements (CPR) Document

The SHELS customer shall prepare a CPR document (appendix E of the CARS) which specifies all interface requirements and parameters. The CPR contains thermal, mechanical, electrical, attitude control, alignment, test and checkout, contamination control, environmental, mission operations, and shipping and handling requirements. It also includes customer-prepared interface drawings and schematics. Requirements over and above those noted in the CPR shall need specific authorization and documentation by Hitchhiker.

Upon signature of the CPR, the SHELS customer agrees to meet all the applicable requirements, i.e. mechanical, electrical, and thermal interfaces and deliverables, safety assessments and deliverables, etc., as specified herein and the CARS document, for flight as a Hitchhiker SHELS payload.

3.1.2 SHELS Interface Control Document (ICD)

Upon signature of the CPR, Hitchhiker shall develop with the customer a SHELS to customer satellite ICD. The ICD defines and details specific interfaces and requirements between the SHELS carrier hardware and the customer satellite hardware, i.e. specific pin-outs, etc. A secondary function of the ICD is to define responsibility for end product deliverables. The ICD is meant to be an agreement between Hitchhiker and the customer to delegate specific hardware assignments.

3.1.3 Safety Data Package (SDP)

The SHELS customer shall prepare Safety Data Packages (SDPs) for both flight and ground phases to ensure compliance with payload requirement documents and NASA payload safety policy. The requirements are contained in the following documents: NSTS 1700.7, *Safety Policy and Requirements for Payloads using the Space Transportation System*; KHB 1700.7, *Space Shuttle Payload Ground Safety Handbook*; and NSTS 13830, *Payload Safety Review Data Submittal Requirements*. The packages will be submitted to the assigned Hitchhiker Safety Engineer. The SDP will be incorporated into integrated flight and ground SHELS SDP's that are presented to the Payload Safety Review Panel (PSRP) and the Ground Safety Review Panel (GSRP), respectively. As part of the process, a Verification and Tracking Log (VTL) will be generated from the Hazard Reports. Each item is tracked and updated. All SHELS customer ground safety VTL items must be closed prior to spacecraft shipment to GSFC. The flight hazards shall be closed out no later than 2 weeks prior to Launch.

The timeline for data submittal is noted in Table 3-1 of this document. All questions concerning safety requirements and documentation should be directed to the contact noted in section 1.2, *Point of Contact*.

3.2 SHELS Procedural Milestones

Table 3-1: Milestone Schedule for Typical Hitchhiker Payloads

STANDARD SERVICES	DATE TO BE COMPLETED (MOS.)
SHELS customer organization submits form 1628	L-24
SHELS customer submits CPR to GSFC/SSPPO	L-24
SHELS customer accommodation meeting at GSFC	L-23
SHELS customer submits preliminary Phase 0/I Safety Data and Structural Integrity Verification Plan	L-20
SHELS customer submits Phase II Safety Data Package	L-14
SHELS customer submits Structural Integrity Verification Report	L-13
SHELS customer submits Phase III Safety Data Package	L-8
SHELS customer hardware delivered to GSFC	L-7
SHELS customer /carrier integration completed	L-6
Hitchhiker payload shipped to launch site	L-4
Hitchhiker payload installed in Orbiter	L-3
L A U N C H	L-0
SHELS customer equipment returned	L+1

4.0 SPACECRAFT REQUIREMENTS

4.1 Envelopes

NASA assumes that most SHELS customers will require a thermal shroud to protect the spacecraft from the cargo bay environment prior to ejection from the Shuttle. Payload envelope is based on thermal shroud dimensions.

The allowable static spacecraft envelope for payloads is shown in Figure 4-1. The spacecraft must also conform to the stiffness limits specified in Section 4.2.4, *Vibration Frequency Constraints*. If dimensions are maintained within this envelope, there will be no contact between the spacecraft and thermal shroud during any phase of the mission. Protrusions outside the envelopes presented are allowed but require coordination and approval from Hitchhiker.

NASA will perform a clearance layout and analysis for each payload to ensure positive clearance during flight. For NASA to complete this assessment, spacecraft descriptions must include an accurate definition of the physical location of all points on the spacecraft that are within one inch of the allowable envelope. The dimensions must include the maximum manufacturing tolerances.

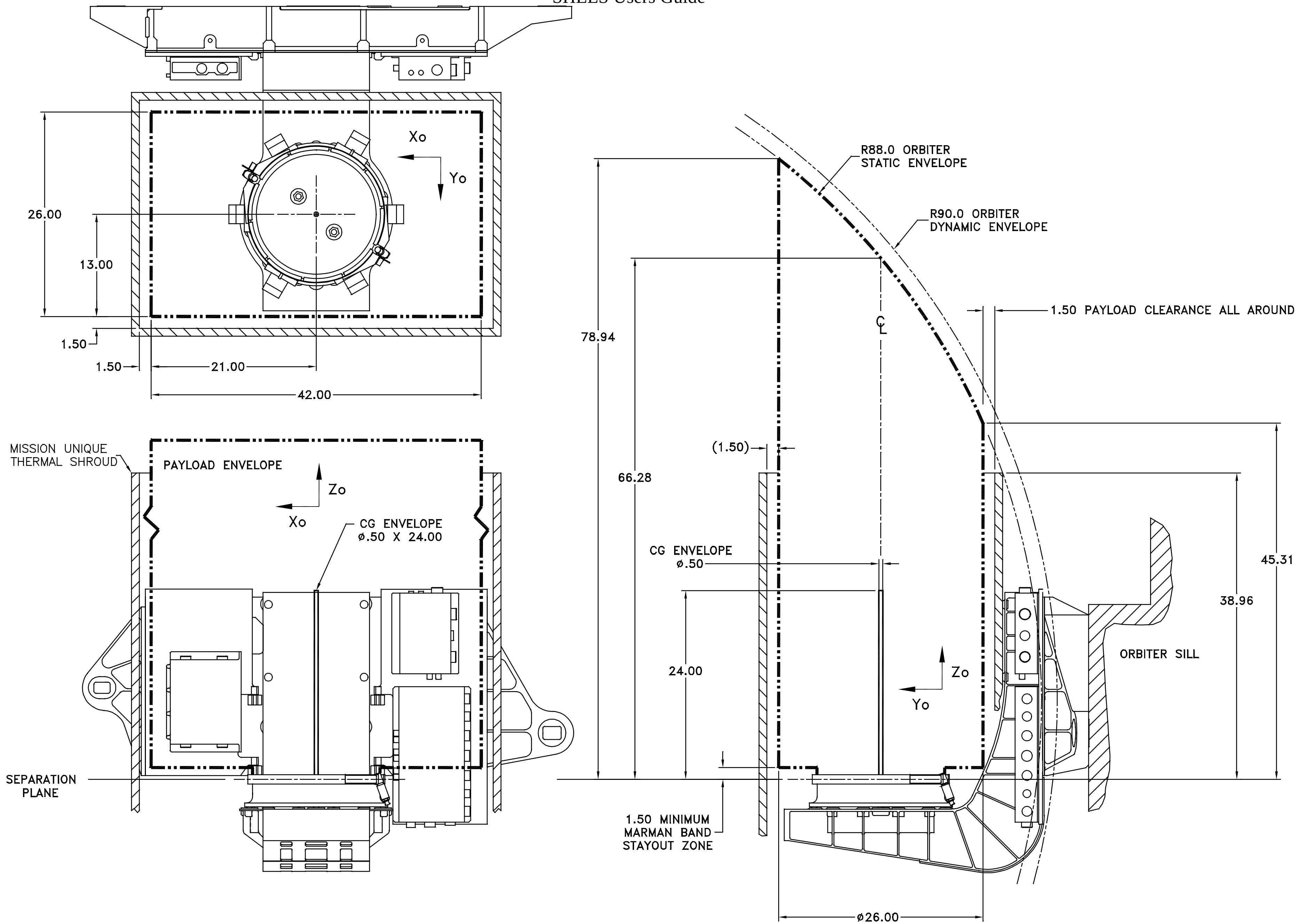


Figure 4-1:SHELS Static Envelope

CHECK THE GSFC CONFIGURATION MANAGEMENT SYSTEM AT
http://sspp-cm.gsfc.nasa.gov/gsfc_cm/plsql/cmdoor to verify the latest version prior to use.

4.2 Design Requirements

All spacecraft must be designed to be "safe without services". This means that the spacecraft must pose no hazard to the Orbiter, even if no data, power, or crew services are available. The following paragraphs discuss further requirements to be considered in any SHELS customer spacecraft design.

4.2.1 Mass Properties

Preliminary spacecraft weight, CG, moments and products of inertia (about the spacecraft CG) shall be provided in the CPR document. The basis for these numbers shall also be provided (i.e., estimated, calculated from fabrication drawings, or actually measured). The customer must provide measured spacecraft weight, CG and mass moments of inertia data to Hitchhiker for incorporation into the overall SHELS payload finite element and dynamic models. Mass properties shall be reported using the following units: inches, pounds, and slug-ft^2. The spacecraft CG must stay within the 24 inch high by 0.5- inch diameter envelope shown in Figure 4-1.

4.2.2 Spacecraft Integrity and Factors of Safety

All SHELS spacecraft shall be designed to withstand the launch, on-orbit, reentry, and landing environments of the Orbiter without failures, leaking hazardous fluids, or releasing anything that could damage the Orbiter or cause injury to the crew. The spacecraft shall be subjected to structural testing at 1.25 times limit loads. Structural analysis must show positive margins with safety factors of 1.25 on yield and 1.4 on all ultimate failure modes, such as material failure or buckling. Alternatively, if the customer qualifies the spacecraft by analysis alone, he must show positive margins of safety with safety factors of 2.0 on yield and 2.6 on ultimate. Verifying structural integrity by analysis alone, without strength testing, is permissible if the customer provides an acceptable engineering rationale. Increasing the design factors of safety does not, by itself, justify this "no-test" approach. Some examples of criteria for this approach can be found in NASA-STD-5001, Section 4.1.2.3. Users choosing to perform structural verification by analysis alone should review their qualification plans with Hitchhiker early in their program for approval. Pressure vessels, lines, fittings, and sealed containers shall be designed in accordance with NSTS 1700.7B.

4.2.3 Limit Acceleration Load Factors

Table 4-1 provides generalized design limit load factors for a SHELS customer spacecraft. These loads envelope the worst case launch and landing load environment, which is a combination of steady state, low frequency, transient loads and high frequency vibration loads. NASA may supply refined design loads, which would be lower, after an updated, higher-fidelity Shuttle math model is released. Final flight limit loads will be derived from the Shuttle coupled loads analysis performed for the Shuttle mission on which the customer is manifested. Smaller, nonstructural components and assemblies mounted to the spacecraft should be designed using load factors that account for the transmissibility between the spacecraft primary structure and the component or assembly. When the transmissibility cannot be measured or estimated adequately, the loads given in Tables 4-1 and 4-2 shall be used. Use of loads other than those in Tables 4-1 and 4-2 for safety critical components/assemblies requires Hitchhiker approval.

The load factors are in g's and should be considered as positive and negative, simultaneous, and in all possible combinations. All accelerations should be applied through the spacecraft's center of mass using the Orbiter coordinate system, as shown in Figure 4-2. Any thermally induced loading shall be combined with the above loads. On orbit thermal loading must also be considered. GSE must be designed using a factor of safety of 5.0 for ultimate failure.

Table 4-1: Hitchhiker Payload/Instrument Structure Design Limit Load Factors

	Load Factor (g)	
NX	NY	NZ
±11.0	±11.0	±11.0

Table 4-2: Hitchhiker Tertiary Assembly/Component Design Load Factors

Weight (lb)	Load Factor (g)
<20	40
20-50	31
50-100	22

The above load factor shall be applied in most critical direction with 30% of the load factor applied in the remaining two directions.

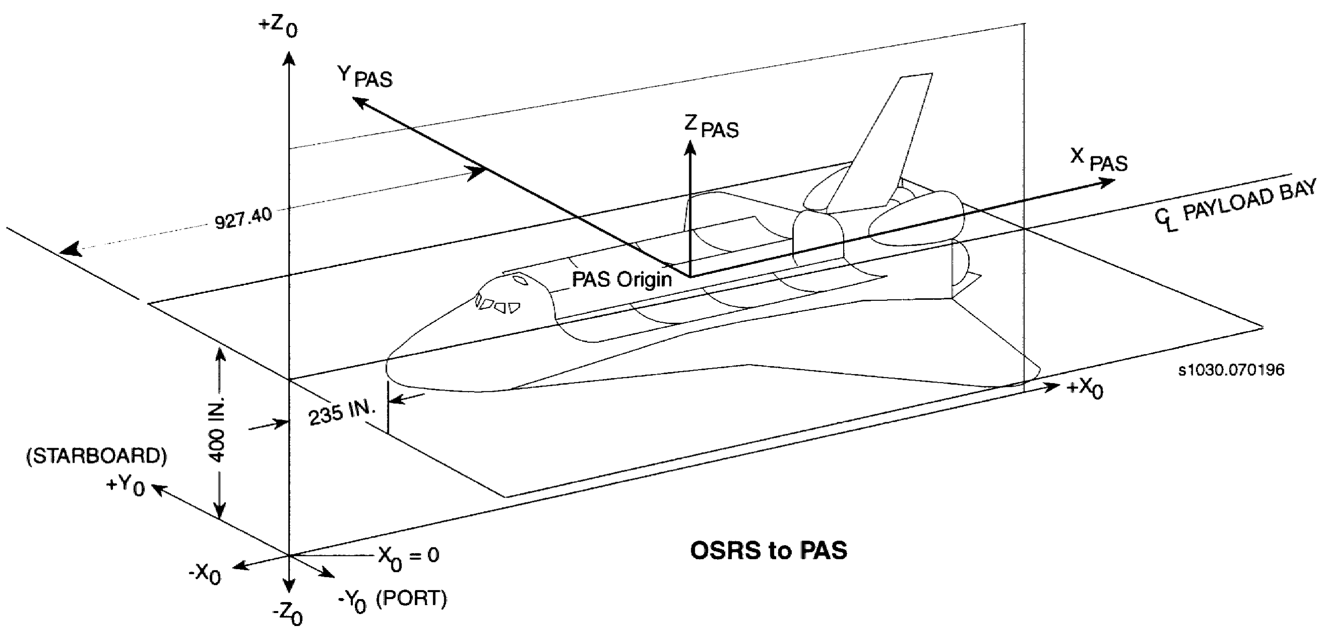


Figure 4-2: Orbiter Coordinate System

4.2.4 Vibration Frequency Constraints

SHELS spacecraft shall have a lowest natural frequency of 35 Hz or greater (single point constraint at the ejection system interface). It is desirable to have the lowest natural frequency above 50 Hz. Verification requirements increase significantly for a payload structure with a lower fundamental frequency. These requirements are outlined in section 4.3.2, *Structural Modeling Requirements.*

4.2.5 Random Vibration and Acoustic Noise

SHELS spacecraft shall be designed to withstand the vibroacoustic environment of the Orbiter without failure. General Orbiter component random vibration test specifications are included in section 4.4.3, *Random Vibration Testing*.

4.2.6 Pressure Profile

Figure 4-4 defines the Orbiter payload bay internal pressure history to be used by the customer for design and venting analyses. Orbiter payload bay vent door opening occurs at altitudes between 70,000 and 94,000 feet. The re-pressurization rate of the payload bay will not exceed 0.3 psi/sec during descent.

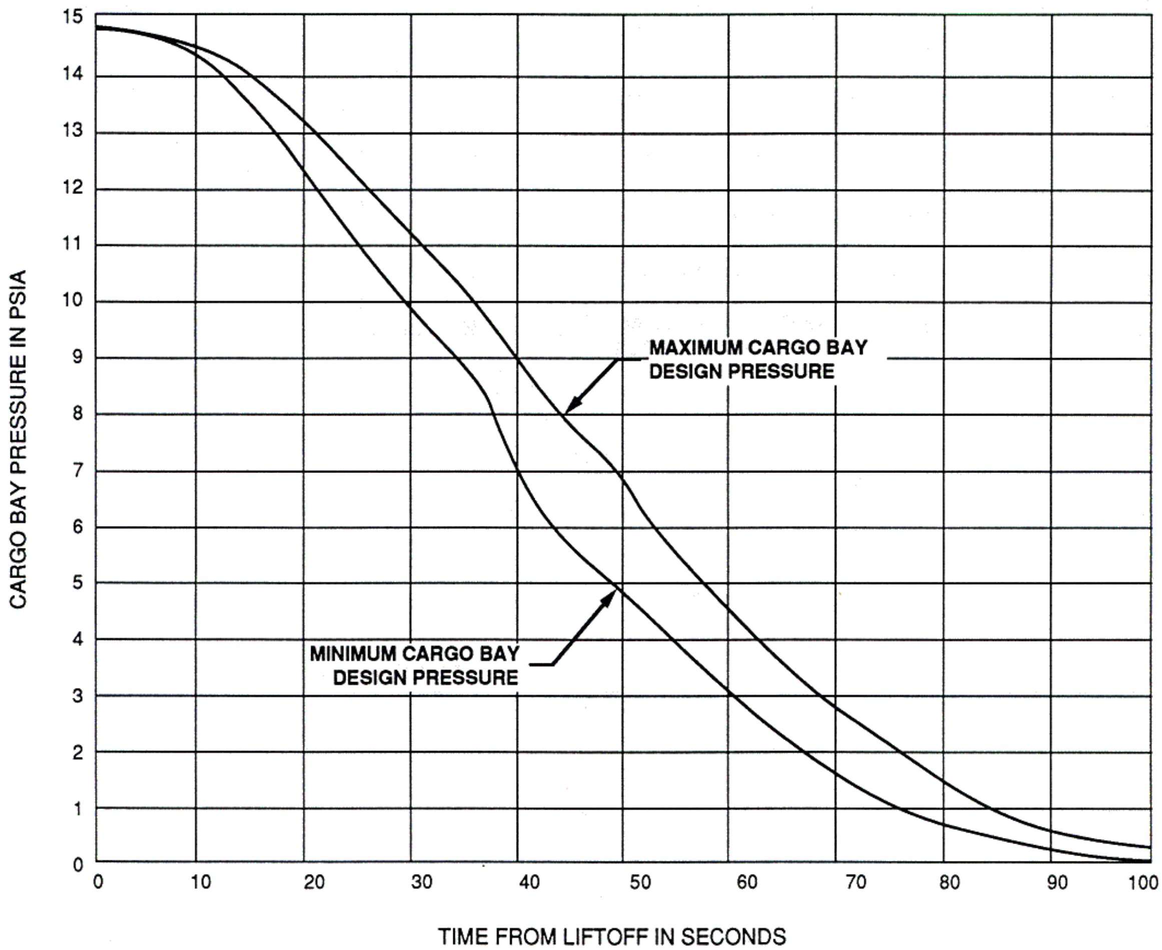


Figure 4-4: Orbiter Payload Bay Internal Pressure Histories During Ascent

4.2.7 Shock Environment

High frequency shock occurs during spacecraft separation from SHELS. As of this SUG version, Hitchhiker has not performed the separation shock testing of SHELS. Future releases will define the shock environment for the SHELS ejection system at the interface. The data will provide an aid in designing spacecraft components that might be sensitive to shock loading. The shock level dissipates rapidly with distance and number of joints between the shock source and the component of interest, as is typical of this type of shock. Shock levels at the interface due to Orbiter events are not significant compared to the spacecraft separation shock. Shock levels will be included in section 4.4.4, *SHELS Shock Testing*

4.2.8 Materials

Allowable mechanical properties of structural materials shall be obtained from MIL-HDBK-5D. Only the materials with high resistance to stress corrosion cracking listed in Table I of the latest version of MSFC-SPEC-522 shall be used. A list of materials must be submitted to Hitchhiker as early in spacecraft development as possible.

4.2.9 Non-Metallic Materials

Use of non-metallic material shall be restricted to those materials which have a maximum collectable volatile condensable material content of 0.1% or less and a total mass loss of 1.0% or less. Hitchhiker will provide the customer a list of approved materials for use in the thermal/vacuum environment upon request.

4.2.10 Sharp Edges and ExtraVehicular Activity (EVA) Compatiblity.

Customer hardware shall be designed to minimize the likelihood of personal injury from contact with sharp corners, edges, protrusions, or recesses. In general, this means rounding exposed edges and corners to a minimum radius of 0.03 inches. Edges and corners at the top of the payload which are near or actually protrude into astronaut EVA sidewall tether corridors shall be suitably protected or rounded to a minimum radius of ½ inch. Edges or protrusions, which for operational reasons cannot meet this requirement, must be coordinated with Hitchhiker on a case by case basis.

4.2.11 Thermal Design Requirements

The thermal design and analysis of each satellite is a customer responsibility. The SHELS customer shall determine all internal conduction, convection, and radiation within their satellite. They shall be responsible for the proper design and coupling of high power components. Reduced thermal models of the satellite are to be supplied to Hitchhiker. Temperature limits, as defined below, shall also be provided for each node in the reduced thermal math model. The SHELS customer shall also define any special temperature requirements, such as levels and gradients.

- Operating Temperature- the temperature at which a unit will successfully function and meet all specifications.

- Non-Operating Temperature- the temperature to which a unit may be exposed in a power OFF condition and if turned ON, will not be damaged. The unit does not have to meet its specification until it is within the operational temperature range.

- Survival Temperature- the temperature, if exceeded, at which the unit will suffer permanent damage.

- Safety Temperature- the temperature, if exceeded, at which the unit could potentially lead to catastrophic damage to the orbiter or injury to the crewmembers.

A list of the payload external surface properties, such as area (size), thermal coatings, absorptivity (α), emissivity ($\in$), and reflectivity, shall be provided by the SHELS customer. The SHELS customer will be responsible for obtaining approval from Hitchhiker regarding any proposed nonstandard thermal coatings. They shall also be responsible for providing heaters on the experiment provided hardware. The heater specification along with the predicted dissipation, duty cycle and HH bus usage shall be supplied to Hitchhiker.

The customer must also be aware of all safety concerns of their payloads, including that the experiment must be safe without services, i.e. remain safe in the event of a power loss. Payloads must also be safe to land 40 minutes after PLBD closure, occurring anytime during the mission. In addition to performing all safety analysis, all payloads must be able to fly in the following attitudes as stated in the Orbiter core ICD-2-19001: a continuous bay-to-Earth attitude; 30-minute solar excursions; 90 minute deep space viewing; and the Space Station X-axis Perpendicular to the Orbital Plane (XPOP) attitude. It is desirable to be able to withstand these extreme cases longer than the ICD requirement for manifesting reasons. Longer runs are required for determining safety concerns, such as the Maximum Design Pressure (MDP), temperatures, and battery limitations. The transient behavior of the experiment should be considered in all thermal analysis for the aforementioned cases.

4.2.12 Thermal Blanket Attachment Requirements

Specific thermal blanket attachment methods are determined on a case-by-case basis depending on payload design, possible contamination constraints, availability of attachment hardware, etc. Typically a combination of various methods is used to attach the blankets to the payload. One mechanical fastener is required as an attach point for thermal blanket grounding. Grounding of thermal blankets shall be in accordance with the Orbiter core ICD-2-19001.

4.2.13 Electromagnetic Capability (EMC)

Spacecraft that use the SHELS umbilical connectors must meet all EMI/EMC conditions as specified in the Orbiter core ICD-2-19001

4.3 Analysis Requirements

4.3.1 Structural Analysis

The customer is required to perform stress analysis in sufficient detail to show that design Factors of Safety are met or exceeded and that a Margin of Safety of zero or greater exists for both yield and ultimate stress conditions, i.e.,

$$MS = \frac{AllowableStress}{(FS)\times(ActualStress)} - 1 \geq 0$$

Stress analysis shall use methods and assumptions consistent with standard aerospace practices. Buckling, crippling, and shear failures shall be considered ultimate failures. Allowable material stresses shall be taken from MIL-HDBK-5.

4.3.2 Structural Modeling Requirements

Customers are required to verify by test all spacecraft natural frequencies under 100Hz. Hitchhiker strongly recommends that the structural stiffness of the spacecraft produce fundamental frequencies above 35Hz in each axis for a spacecraft hard-mounted at the spacecraft separation plane (without ejection base and marman band). A design goal of 50Hz is highly recommended. A customer having a spacecraft with natural frequencies less than 50Hz must submit to Hitchhiker a test-verified finite element math model of their spacecraft. All finite element models submitted to Hitchhiker must demonstrate mathematical validity by showing that the model contains six rigid body frequencies of value 0.001Hz or less. The math model should contain as few degrees of freedom as necessary for accurate simulation of **frequencies and mode shapes** under 50Hz and all **frequencies** up to 100Hz, but in all cases must be limited to no more than 10,000 degrees of freedom. The customer and Hitchhiker will agree, on a case by case basis, on the specific form and content of the finite element math model submitted to Hitchhiker. A finite element math model is not required for spacecraft with a lowest natural frequency above 50Hz, but an analysis (either classical or finite element) is still required to verify natural frequency testing. Table 4-3 summarizes these frequency and modeling requirements. Test verification can be achieved by performing a modal survey or sine sweep test on the payload as discussed in section 4.4.2, *Natural Frequency Verification Testing.*

Table 4-3: Structural Modeling Requirements

Lowest Fundamental Frequency	Required Testing	Analysis Method
$f_N \geq 100$ Hz	none	classical or F.E.M.
50 Hz < f_N < 100 Hz	sine sweep (modal survey acceptable)	classical or F.E.M.
35 Hz < f_N < 50 Hz	modal survey or sine sweep (dependant on modal complexity)*	F.E.M.
$f_N \leq 35$ Hz Note: this range is not recommended	modal survey or sine sweep (dependant on modal complexity)*	F.E.M.

* See Section 4.4.2, *Natural Frequency Verification Testing*

4.3.3 Fracture Control

A fracture control program is required for all SHELS spacecraft. The customer is responsible for providing a Fracture Control Implementation Plan, which describes in detail how the requirements of NASA-STD-5003 (Fracture Control Requirements for Payloads using the Space Shuttle) will be satisfied. The fracture control program implemented by the customer shall provide assurance that no catastrophic hazards to the Orbiter or crew will result from the initiation or propagation of flaws, cracks, or crack-like defects in customer structure during its mission lifetime, including fabrication, testing, and service life. In addition, all customer structural fasteners must comply with GSFC S-313-100 (11/89), *GSFC Fastener Integrity Requirements*. Hitchhiker must approve the plan prior to its implementation. It will normally be included as part of the structural integrity verification plan described earlier.

4.4 Testing Requirements

4.4.1 Structural Test Requirements-Qualification by Test Option

The customer is required to perform strength testing of all structural components. The test must demonstrate that no detrimental permanent deformation or ultimate failures occur when loads are imposed on the spacecraft; these loads must be applied such that every primary load-carrying member experiences a stress of at least 1.25 times the limit stress. The limit stress is the highest stress produced either by design acceleration load factors or by refined loads supplied by Hitchhiker. To satisfy this requirement, it is not necessary to impose the precise externally applied load factors in a single test. One may impose artificial loads in a number of different load cases; each load producing the required stresses in only a portion of the structure. The test must result in the required stresses in all primary load-carrying members. The test load may be applied by pulling on the structure with discrete forces, by the application of a linear acceleration field (centrifuge), or by subjecting the instrument to a below-resonant-frequency sine dwell or sine burst vibration test.

4.4.2 Natural Frequency Verification Testing

All spacecraft shall have its lowest cantilevered natural frequency verified by test if the predicted natural frequency is below 100Hz. Acceptable tests for verifying natural frequencies include modal survey and sine sweep vibration. Hitchhiker may require spacecraft with complicated mode shapes and natural frequencies less than 50Hz to undergo modal survey testing to recover both structural mode frequencies and mode shapes. The decision of whether to require the modal survey will be based on Hitchhiker's engineering judgement and experience.

4.4.3 Random Vibration Testing

All spacecraft must be tested for the Space Shuttle vibroacoustic environment. Table 4-4 provides a generalized vibration specification for Orbiter equipment. Hitchhiker may waive this requirement in some instances, such as reflown or contained hardware. New designs must be tested to qualification levels. Reflown or previously qualified hardware may be tested to acceptance levels. A prototype spacecraft may be used for qualification testing.

4.4.4 Shock Testing

High frequency separation shock levels are difficult to simulate mechanically on a vibration table at a spacecraft level. The most direct method is to perform a test using an Engineering Test Unit (ETU) SHELS ejection system with functional marman band and bolt cutters. The test is performed by installing the ETU SHELS ejection system to the spacecraft and then suspending the entire assembly above foam padding. The ETU is then actuated and allowed to drop on to the foam.

Table 4-4: Generalized Shuttle Component Random Vibration (50 lbs. or less)

Frequency (Hz)	ASD Level (G^2/Hz)	
	Qualification	Acceptance
20 20-50 50-600 600-2000 2000	.025 +6 dB/oct .15 -4.5 dB/oct .025	.0125 +6 dB/oct .075 -4.5 dB/oct .0125
Overall	12.9 G_{rms}	9.1 G_{rms}

The test may be modified and the acceleration spectral density level reduced for components weighing more than 50 pounds by using the following formula:

dB reduction = 10LOG(W/50)

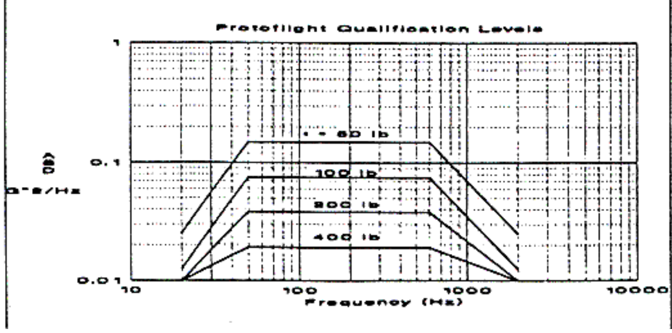
$ASD_{(50\text{-}600Hz)}$ = .15•(50/W) for protoflight

$ASD_{(50\text{-}600\ Hz)}$ = .075•(50/W) for acceptance

Where W = component weight

The slopes shall be maintained at +6 and -4.5 dB/oct for components weighing up to 125 pounds. Above this weight, the slopes shall be adjusted to maintain an ASD level of 0.01 G^2/Hz at 20 and 2000 Hz.

For components weighing over 400 pounds, the test specification shall be maintained at the level for 400 pounds.



Vibration test duration is one minute in each of the three orthogonal axes.

4.4.5 Typical Test Sequence

The fulfillment of the above test requirements can often be satisfied by a single visit to a vibration test facility, depending on the mass and stiffness of the payload. A typical test of this type would include:

a. A sine sweep test to verify the natural frequency,
b. A sine burst test to perform strength testing, and
c. A random vibration to qualify the payload for vibroacoustic environment.

This test sequence would typically be repeated in each axis. It must be remembered, however, that the sine burst applies a force field in a single axis whereas the design load factors occur in all three axes simultaneously.

5.0 PAYLOAD INTERFACES

5.1 Mechanical

The SHELS mechanical system consists of a launch structure, ejection system, and mission unique thermal shroud. The system is designed to accommodate a wide range of spacecraft and provide a cost effective, user friendly launch system with minimum integration. The SHELS system may accommodate up to a 400-pound satellite with a CG no more than 24 inches above the ejection system separation plane. The satellite CG must be within 0.25 inches of the ejection system centerline. The entire system is being modeled in Pro-Engineer™. Figure 5-1 shows a 3-D view of SHELS.

5.1.1 Launch Structure

The SHELS support structure is a premium quality, aerospace, structural casting with a riveted stress-skin panel for increased torsional capability. The casting material is aluminum alloy A356-T6 strength class 10, fabricated with rapid prototype, investment casting techniques. The support structure provides the structural interface to the ABA, which in turn mounts directly to the Orbiter sidewall.

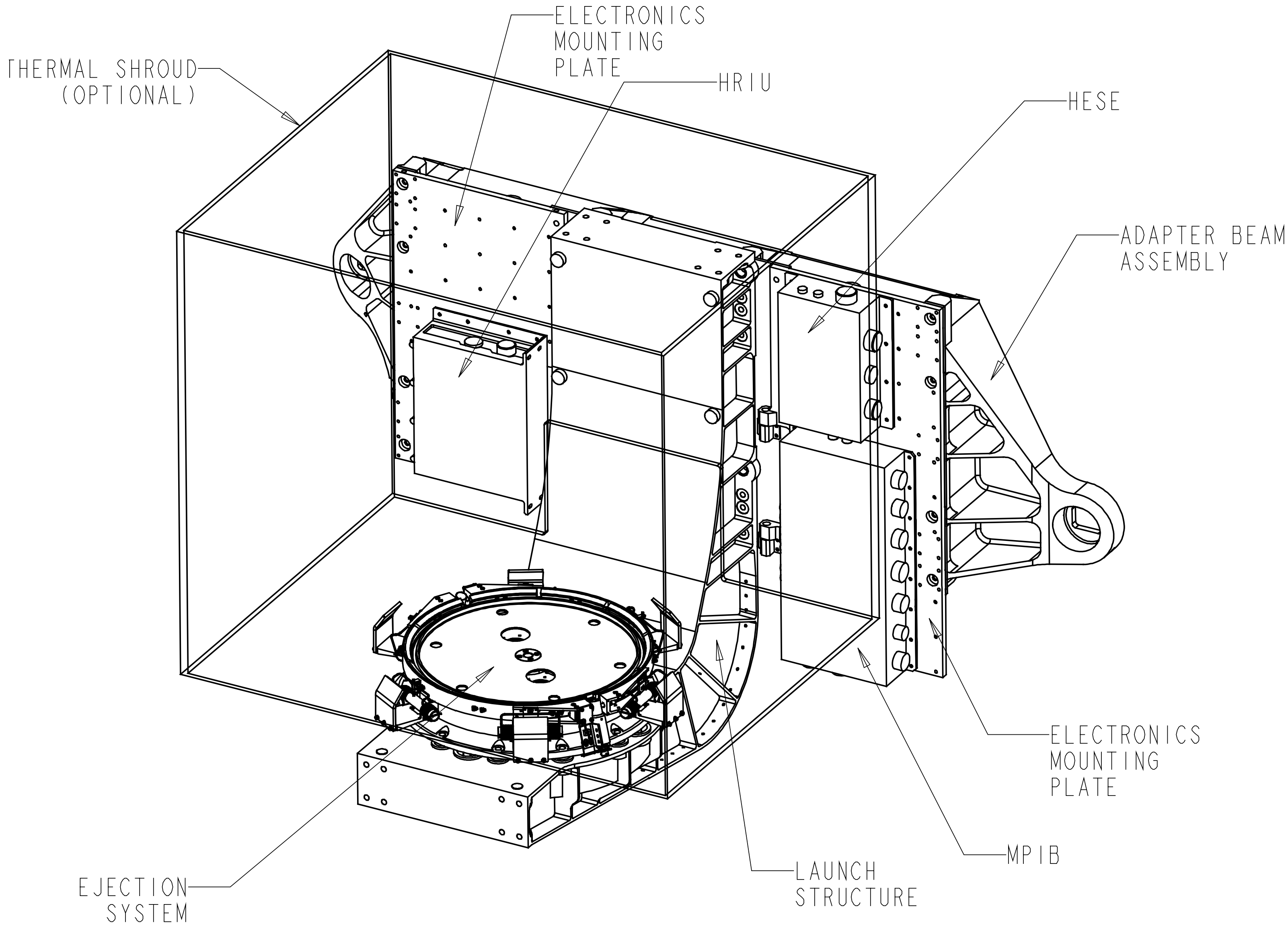


Figure 5-1: 3D Model of SHELS Single Beam Configuration

5.1.2 Ejection System

The SHELS ejection system consists of an ejection base, strap and shoe marman band, center mounted compression spring/push plate assembly, and a torsion spring catcher assembly as shown in Figure 5-2. The thermally isolated ejection base is mounted to the SHELS launch structure. All hardware necessary for mating and separation, e.g. marman band assembly, bolt cutters, and torsion spring assemblies, remain with the ejection base upon spacecraft separation. The SHELS ejection base is approximately 3.5 inches high and is 16.72 inches wide at the marman band flange.

The marman band consists of two stainless steel tension straps and ten shoes which are loosely riveted to the strap. Trunnions are riveted to the ends of each strap and provide a swiveled attach point for the separation bolts which tension the system. The aluminum shoes have a 20° ramp angle and low friction, hard coatings applied to all surfaces. The separation flange configuration and associated spacecraft interface requirements are shown in Figures 5-3 and 5-4.

When the separation bolts are preloaded, the shoes clamp the system by riding up matching ramps on the ejection base flange and payload interface plate flange. Each of the separation bolts will also have a bolt force sensor to monitor band tension during assembly, testing, and under various environmental conditions. The marman band is released by redundant bolt cutters. A nominal separation of the payload from the ejection base will occur if only one of the bolt cutters functions. When the separation bolts are cut, the marman band snaps off the flange interfaces and is held in a retracted position by six torsion spring assemblies.

Once the marman band has snapped off the flanges, a centrally located compression spring is free to push the payload away from the ejection base. A guide shaft, riding in a set of linear ball bearings, guides the push plate during the stroke of the spring. The linear bearings provide a low friction, tightly controlled ejection with low tip off imparted to the payload. A line of balls in each linear bearing also rides in a “V” groove cut down the length of the guide shaft. This arrangement prevents the spring from imparting a rotational input into the payload during ejection. Ejection velocity may be tailored to the payload requirements by placing different size compression springs in the adjustable spring housing. Presently, the maximum ejection velocity for a 400-pound payload is 4 ft/sec with a maximum 5 inch stroke. The ejection velocity is adjustable from 1 ft/sec to 4 ft/sec.

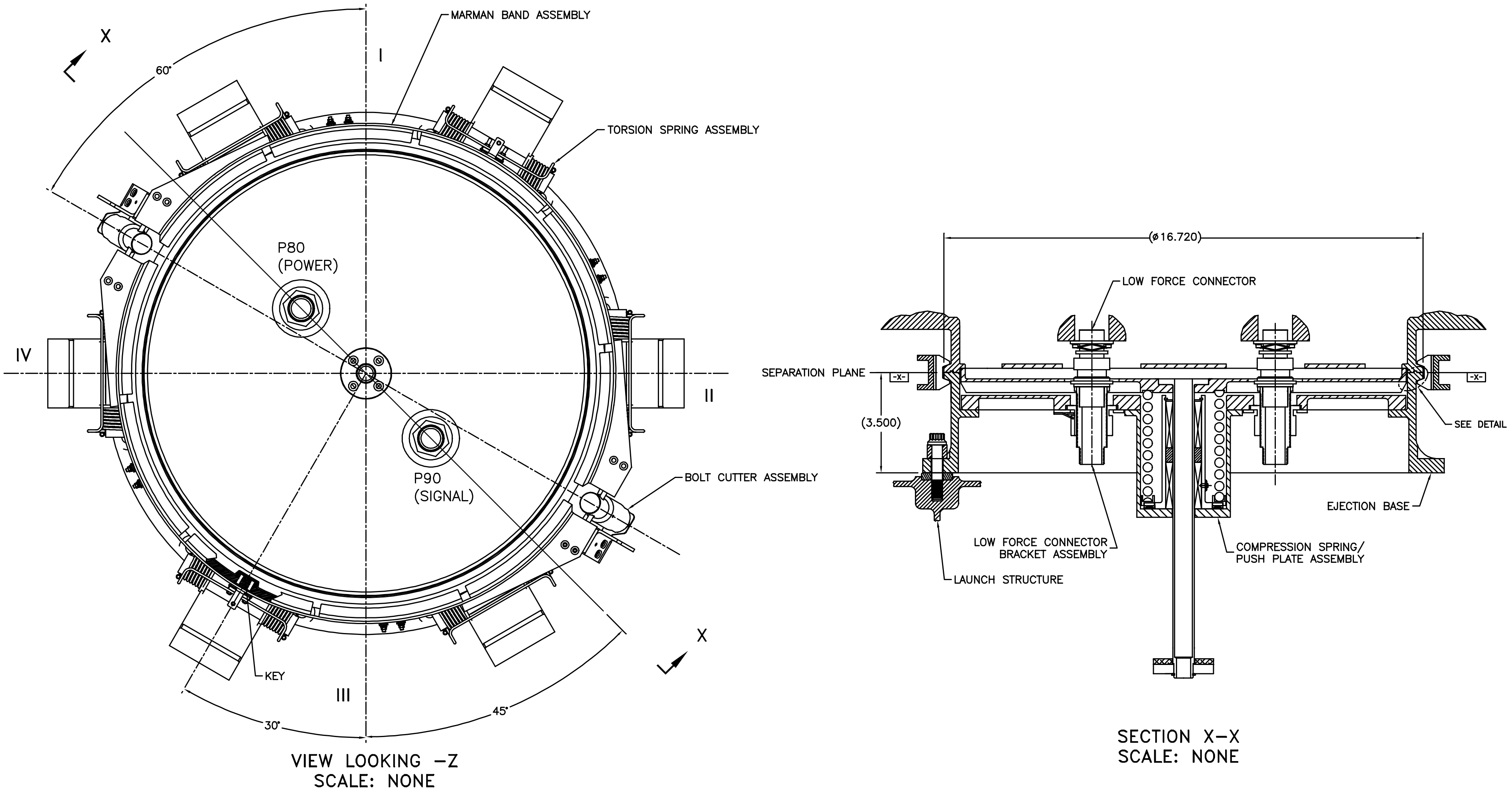


Figure 5-2: SHELS Ejection System

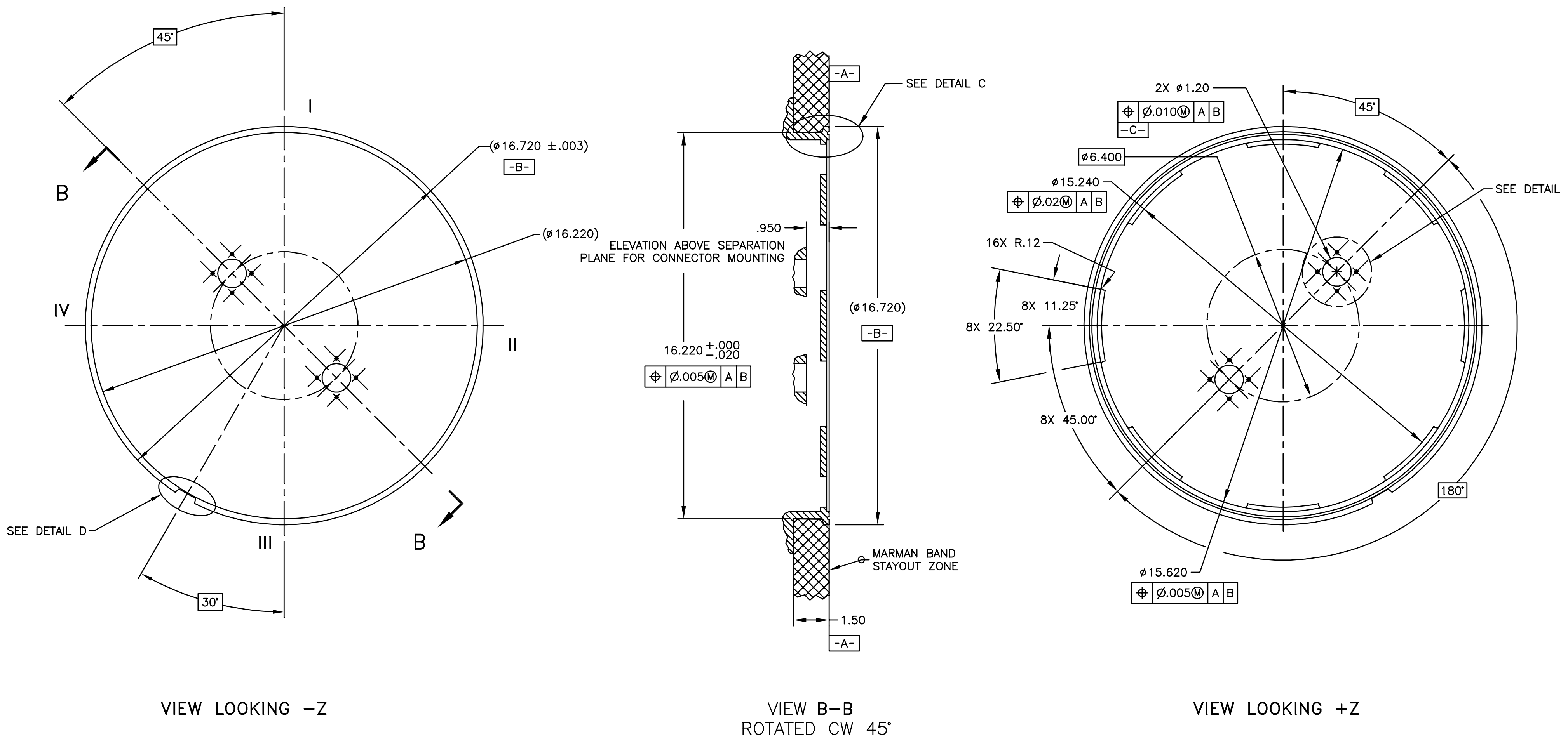


Figure 5-3: SHELS Spacecraft Interface Details

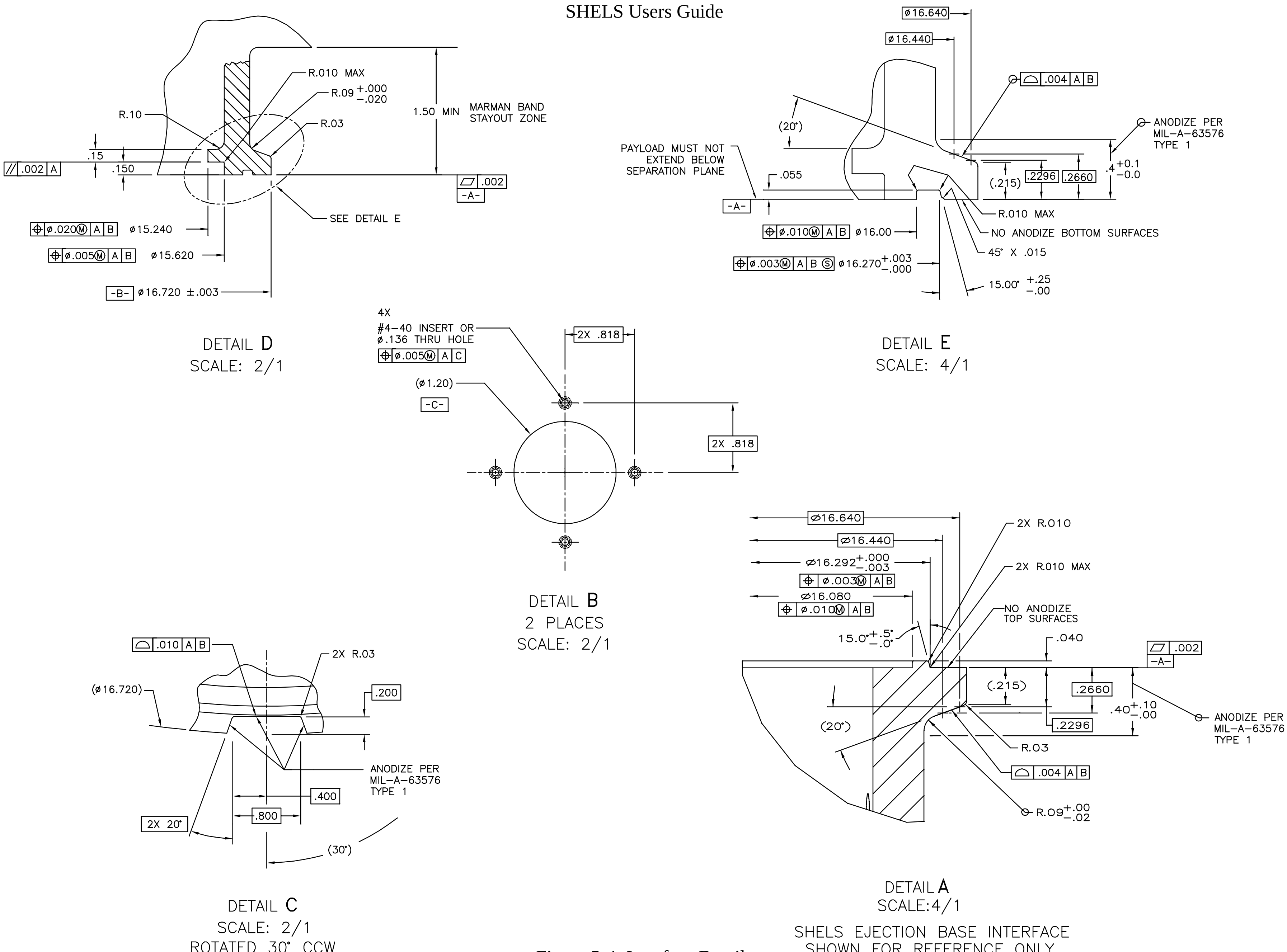


Figure 5-4: Interface Details

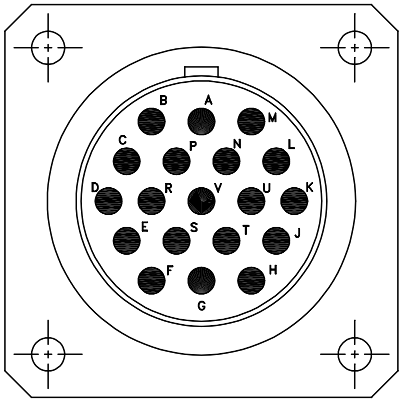
The ejection system allows for the mounting of two low force umbilical connectors. The connectors provide power and telemetry to the payload while it is in the payload bay, prior to ejection. The connectors incorporate a set of wave springs on one half of the connector and an adjustable nut on the other half. By adjusting the location of the nut, the friction force of the contacts can be negated, essentially creating a low force separation connector. The two connectors are mounted on adjustable brackets on the ejection base plate next to the compression spring assembly. The adjustable bracket allows for a blind mate of the connector during payload integration. Figure 5-5 shows the pin-outs for the two umbilical connectors.

5.2 Electrical

5.2.1 Electrical System Overview

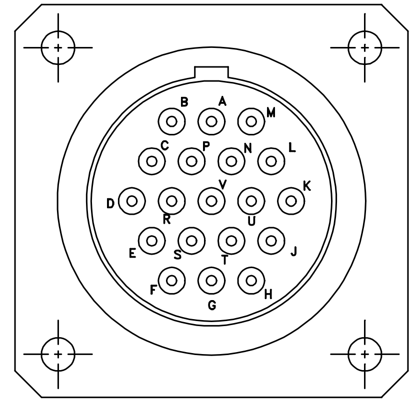
Figure 5-6 represents the electrical interfaces for the single beam system approach for the SHELS. This configuration uses a Payload General and Support Computer (PGSC), operated by the crew, for telemetry and limited command processing of the carrier hardware. The electrical carrier hardware includes the following: HH Ejection System Electronics (HESE), HH Remote Interface Unit (HRIU), Multipurpose Interface Box (MPIB), and shroud heater circuits. The Standard Switch Panel (SSP) will be utilized for power switching and satellite deployment control. If the SHELS customer has opted to implement the umbilical interface, then satellite command and telemetry processing will also be performed with the PGSC.

Figure 5-7 represents the electrical interfaces for the dual beam system approach for SHELS. This implementation utilizes the HH Avionics (Standard or Advanced) for ground command and telemetry processing, and power distribution for the carrier hardware. The Standard Switch Panel (SSP) provides the power and signal interface to the HH Avionics and controls. If the SHELS customer has opted to implement the umbilical interface, then satellite command and telemetry processing will also be performed through the HH Avionics from the Payload Operations Control Center (POCC) located at GSFC, or other negotiated location. Details on implementation of the Avionics, HRIU, and HESE interfaces may be found in the HH CARS document.



SHELS J80
POWER UMBILICAL INTERFACE DEFINITION
P/N: NEA14000-1519RP
CONNECTOR FACE VIEW SATELLITE SIDE
● REPRESENTS PINS

CONTACT	DESCRIPTION	COMMENT
A	+28V POWER A	CURRENT LIMIT TO LESS $\leq$ 2.5A
B	+28V RETURN	CURRENT LIMIT TO LESS $\leq$ 2.5A
C	+28V POWER B	CURRENT LIMIT TO LESS $\leq$ 2.5A
D	+28V RETURN	CURRENT LIMIT TO LESS $\leq$ 2.5A
E	+28V POWER C	CURRENT LIMIT TO LESS $\leq$ 2.5A
F	+28V RETURN	CURRENT LIMIT TO LESS $\leq$ 2.5A
G	+28V POWER D	CURRENT LIMIT TO LESS $\leq$ 2.5A
H	+28V RETURN	CURRENT LIMIT TO LESS $\leq$ 2.5A
J	SATELLITE AUXILIARY 1	USER DEFINED
K	SATELLITE AUXILIARY 2	USER DEFINED
L	SATELLITE AUXILIARY 3	USER DEFINED
M	SATELLITE AUXILIARY 4	USER DEFINED
N	SATELLITE AUXILIARY 5	USER DEFINED
P	SATELLITE AUXILIARY 6	USER DEFINED
R	SATELLITE AUXILIARY 7	USER DEFINED
S	SATELLITE AUXILIARY 8	USER DEFINED
T	SATELLITE AUXILIARY 9	USER DEFINED
U	SATELLITE AUXILIARY 10	USER DEFINED
V	SATELLITE AUXILIARY 11	USER DEFINED



SHELS J90
SIGNAL UMBILICAL INTERFACE DEFINITION
P/N: NEA14000-1519RS
CONNECTOR FACE VIEW SATELLITE SIDE
◎ REPRESENTS SOCKETS

CONTACT	DESCRIPTION	COMMENT
A	SATELLITE ANALOG 1	LEVEL 0-5V
B	SATELLITE ANALOG 2	LEVEL 0-5V
C	SATELLITE ANALOG 3	LEVEL 0-5V
D	SATELLITE ANALOG SHIELD	CHASSIS
E	SATELLITE ASYNCHRONOUS RD +	1200bps
F	SATELLITE ASYNCHRONOUS RD -	-
G	SATELLITE ASYNCHRONOUS RD SHIELD	CHASSIS
H	SATELLITE ASYNCHRONOUS RD +	1200bps
J	SATELLITE ASYNCHRONOUS RD -	-
K	SATELLITE ASYNCHRONOUS RD SHIELD	CHASSIS
L	SATELLITE MET MINUTE PULSE	-
M	SATELLITE MET MINUTE PULSE SHIELD	CHASSIS
N	SATELLITE Bi-LEVEL 1	0 OR ~24V
P	SATELLITE Bi-LEVEL 2	0 OR ~24V
R	SATELLITE Bi-LEVEL 3	0 OR ~24V
S	SATELLITE AUXILIARY 12	USER DEFINED
T	SATELLITE AUXILIARY 13	USER DEFINED
U	SATELLITE AUXILIARY 14	USER DEFINED
V	SATELLITE AUXILIARY 15	USER DEFINED

Figure 5-5: Connector Pin-outs

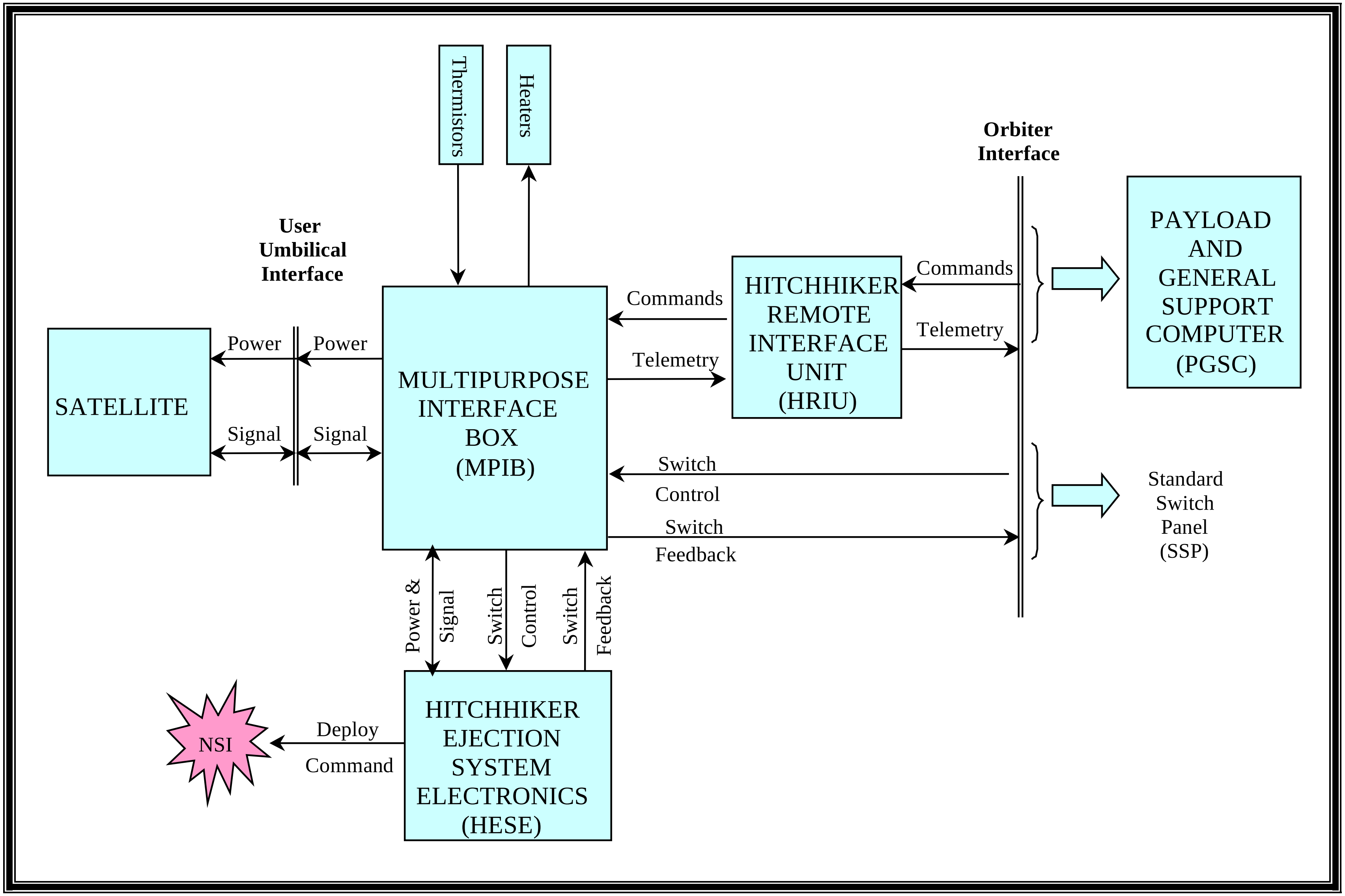


Figure 5-6: SHELS HRIU Configuration (single beam)

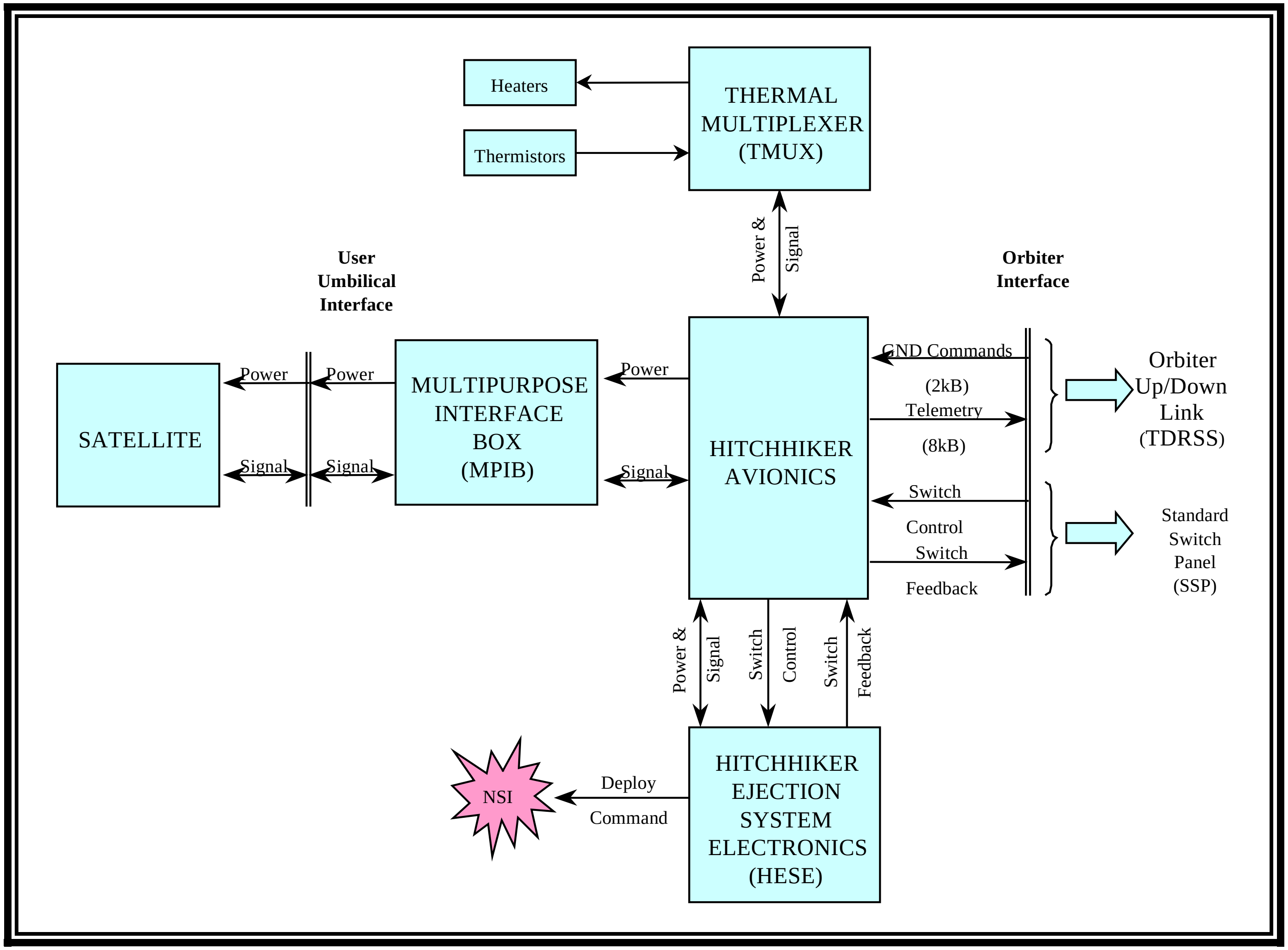


Figure 5-7: SHELS Avionics Configuration (two beam)

5.2.2 Umbilical Connector Interfaces

SHELS provides electrical support capabilities via the umbilical interface to the carrier through the Multipurpose Interface Box (MPIB). The MPIB provides fusing and power distribution, and signal isolation. The umbilical interface from the MPIB to the satellite consists of two custom nineteen contact negative force connectors, one defined primarily for power, the other for signal, with any unused contacts defined as auxiliary usage. Additionally, for ground processing an Auxiliary interface to the satellite is provided. Figure 5-8 illustrates the satellite specific interfaces with the MPIB. In this diagram, P/J80 represents the power umbilical and P/J90 represent the signal umbilical, with both connectors located at the ejection system / satellite interface plane. The auxiliary interface, identified as J10, will be mounted to an access bracket, and will be installed on a separate electronics mounting plate.

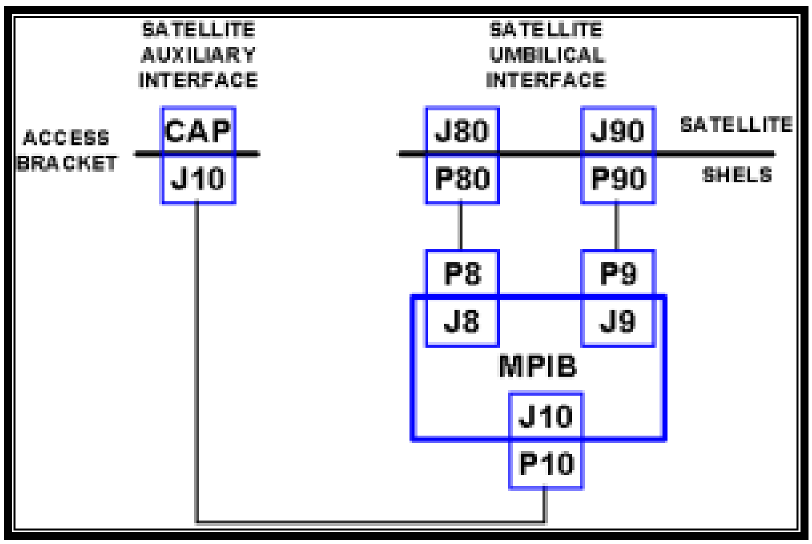


Figure 5-8: Customer Interfaces with SHELS

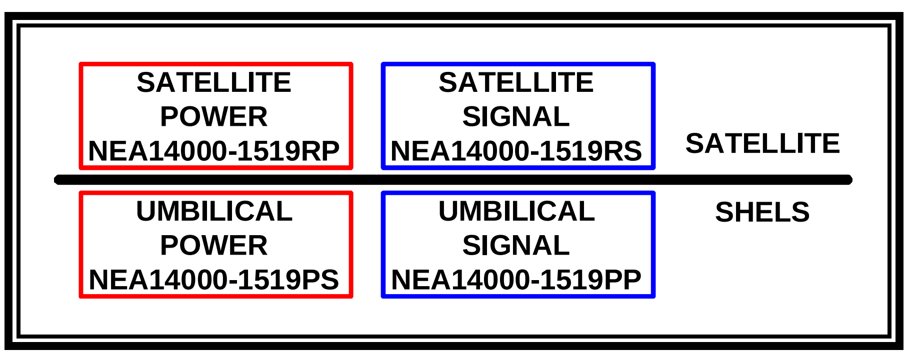


Figure 5-9: SHELS Umbilical Connector Definition

5.2.2.1 Umbilical Power Interface

Umbilical power is delivered to the satellite through MPIB connector J8 and subsequently to the umbilical J80. The power delivered to the satellite may be used for any purpose, if approved through the safety process, but may impose constraints on the analog telemetry. For example, using umbilical power for onboard satellite heaters will require using at least one of the analog telemetry inputs for thermal monitoring. The power delivered to the satellite is limited to 10A, or 280W at 28V, the standard orbiter bus voltage, with the distribution system illustrated in Figure 5-10. The satellite power bus is diode-isolated from the carrier bus and delivered on four 20 AWG wire pairs fused on the supply side and returned to a single return bus. If combined on the satellite side into a single power bus, fusing will be required on the spacecraft side to prevent smart shorts (ref TA-92-032). The user's power interface is defined in Table 5-1a.

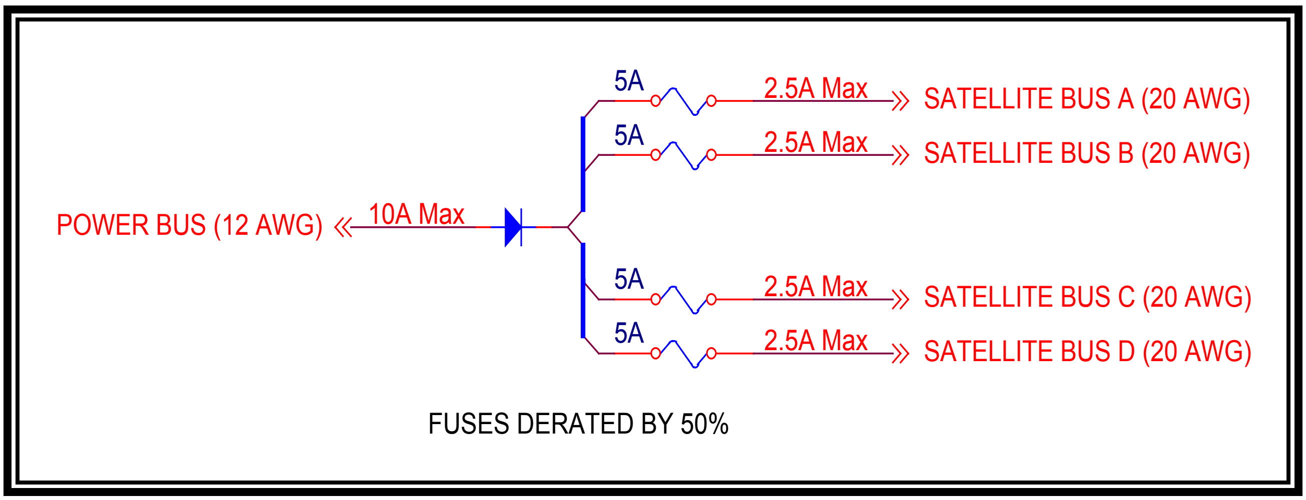


Figure 5-10: MPIB Satellite Power Distribution

Table 5-1a: SHELS Umbilical Power Interface Definition (J80)

CONTACT	DESCRIPTION	COMMENT
A	+28V Power A	Current limit to ≤ 2.5A
B	+28V Return	Current limit to ≤ 2.5A
C	+28V Power B	Current limit to ≤ 2.5A
D	+28V Return	Current limit to ≤ 2.5A
E	+28V Power C	Current limit to ≤ 2.5A
F	+28V Return	Current limit to ≤ 2.5A
G	+28V Power D	Current limit to ≤ 2.5A
H	+28V Return	Current limit to ≤ 2.5A
J	Satellite Auxiliary 1	User Defined
K	Satellite Auxiliary 2	User Defined
L	Satellite Auxiliary 3	User Defined
M	Satellite Auxiliary 4	User Defined
N	Satellite Auxiliary 5	User Defined
P	Satellite Auxiliary 6	User Defined
R	Satellite Auxiliary 7	User Defined
S	Satellite Auxiliary 8	User Defined
T	Satellite Auxiliary 9	User Defined
U	Satellite Auxiliary 10	User Defined
V	Satellite Auxiliary 11	User Defined

5.2.2.2 Umbilical Signal Interface

The umbilical signal interface services available to the satellite are a sub-set of that provided by a standard HH Avionics signal port. The umbilical signal interface, which uses opto-isolation circuitry, consists of the following capabilities:

- Low Rate Asynchronous Command and Telemetry, 1200bps (ASYNC)- See Figure 5-11 and Figure 5-12 for the Command (SD) and Telemetry (RD) electrical interfaces.
- Mission Elapsed Time Minute Pulse (METMIN)- See Figure 5-13 for the METMIN electrical interface.
- Bi-level controls, may be pulses- See Figure 5-14 for the Bi-level electrical interface.
- Analog 0-5V telemetry- See Figure 5-15 for the Analog 0-5V telemetry electrical interface.

The satellite contact definition is shown in Table 5-1b.

Table 5-1b: SHELS Umbilical Signal Interface Definition (J90)

CONTACT	DESCRIPTION	COMMENT
A	Satellite Analog 1	Level 0-5V
B	Satellite Analog 2	Level 0-5V
C	Satellite Analog 3	Level 0-5V
D	Satellite Analog Shield	Chassis
E	Satellite Asynchronous RD +	1200 bps
F	Satellite Asynchronous RD -	
G	Satellite Asynchronous RD Shield	Chassis
H	Satellite Asynchronous SD +	1200bps
J	Satellite Asynchronous SD -	
K	Satellite Asynchronous SD Shield	Chassis
L	Satellite MET Minute Pulse	
M	Satellite MET Minute Pulse Shield	Chassis
N	Satellite Bi-level 1	0 or ~ 24V
P	Satellite Bi-level 2	0 or ~ 24V
R	Satellite Bi-level 3	0 or ~ 24V
S	Satellite Auxiliary 12	User Defined
T	Satellite Auxiliary 13	User Defined
U	Satellite Auxiliary 14	User Defined
V	Satellite Auxiliary 15	User Defined

5.2.2.3 Auxiliary Interface

The auxiliary interface has been designed to allow the SHELS customer to access the satellite without requiring the HH electrical systems to be active. The intent of this interface is to allow the SHELS customer the ability for offline processing, including by way of an example, firmware updates, health and status checkups, battery top charging (safety approval), et cetera. The power and signal interfaces to the satellite are shared with those of the carrier electronics, i.e. hardwired OR, except the Analog Telemetry. The power delivered to the satellite from the customer ground support equipment will require the proper fusing, as shown by analysis, as the fusing inside the MPIB is bypassed during the auxiliary access mode. The auxiliary signal interface is defined in Table 5-1c.

Table 5-1c : SHELS Satellite Auxiliary Interface Definition (J10)

CONTACT	DESCRIPTION	COMMENT
A	Satellite Auxiliary 1	User Defined
B	Satellite Auxiliary 2	User Defined
C	Satellite Auxiliary 3	User Defined
D	Satellite Auxiliary 4	User Defined
E	Satellite Auxiliary 5	User Defined
F	Satellite Auxiliary 6	User Defined
G	Satellite Auxiliary 7	User Defined
H	Satellite Auxiliary 8	User Defined
J	Satellite Auxiliary 9	User Defined
K	Satellite Auxiliary 10	User Defined
L	Satellite Auxiliary 11	User Defined
M	Satellite GSE Power A	Current limit to ≤ 2.5A
N	Satellite GSE Return	Current limit to ≤ 2.5A
P	Satellite GSE Power B	Current limit to ≤ 2.5A
R	Satellite GSE Return	Current limit to ≤ 2.5A
S	Satellite GSE Power C	Current limit to ≤ 2.5A
T	Satellite GSE Return	Current limit to ≤ 2.5A
U	Satellite GSE Power D	Current limit to ≤ 2.5A
V	Satellite GSE Return	Current limit to ≤ 2.5A
W	Satellite Analog Telemetry 1	
X	Satellite Analog Telemetry 2	
Y	Satellite Analog Telemetry 3	
Z	Satellite Analog Telemetry Shield	
a	Satellite Asynchronous RD+	
b	Satellite Asynchronous RD-	
c	Satellite Asynchronous RD Shield	
d	Satellite Asynchronous SD+	
e	Satellite Asynchronous SD-	
f	Satellite Asynchronous SD Shield	
g	MET Minute Pulse	
h	MET Minute Pulse Shield	
i	Bi-level 1	
j	Bi-level 2	
k	Bi-level 3	
m	Satellite Auxiliary 12	User Defined
n	Satellite Auxiliary 13	User Defined
p	Satellite Auxiliary 14	User Defined
q	Satellite Auxiliary 15	User Defined
r	Unused	Unused
s	Unused	Unused
t	Unused	Unused

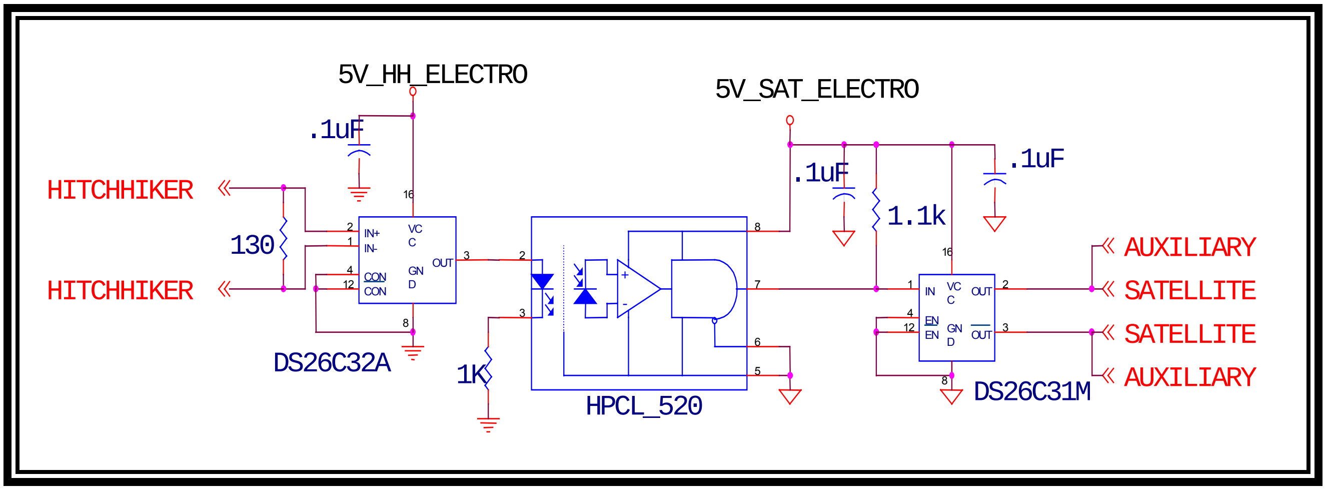


Figure 5-11: MPIB Send Data (SD) Isolation Implementation

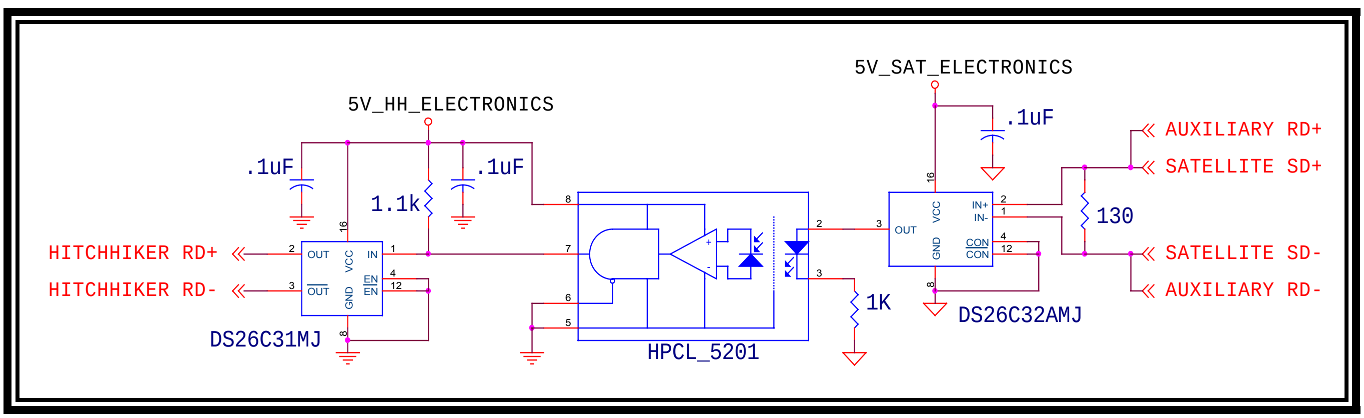


Figure 5-12: MPIB Receive Data (RD) Isolation Implementation

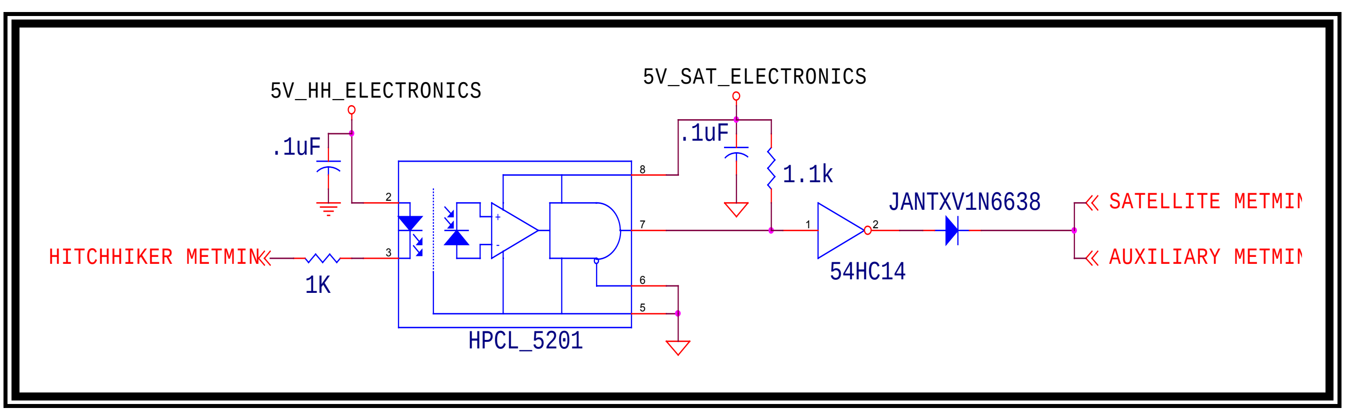


Figure 5-13: MPIB MET Minute Pulse Isolation Implementation

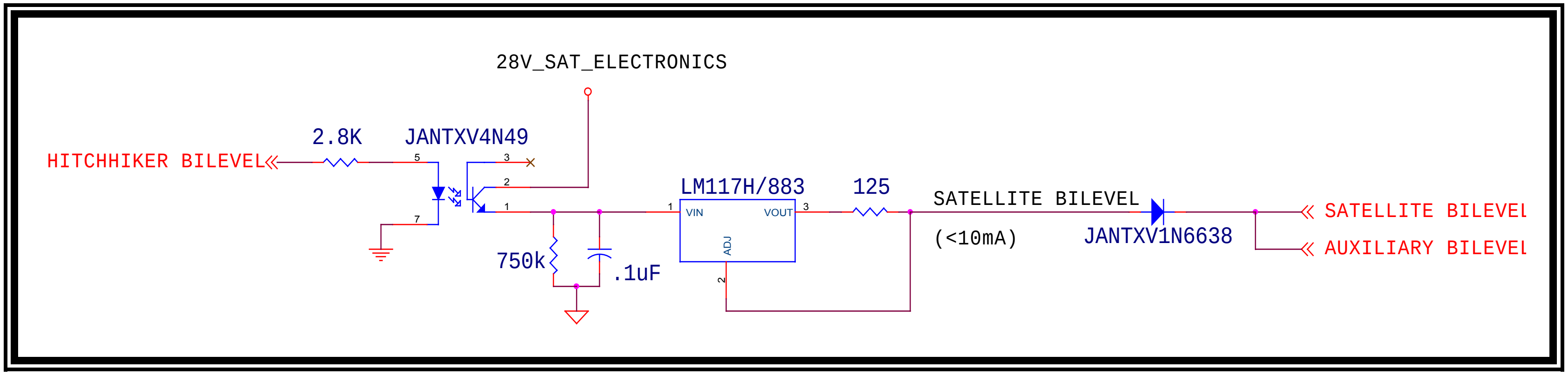


Figure 5-14: MPIB Bi-level Isolation Implementation

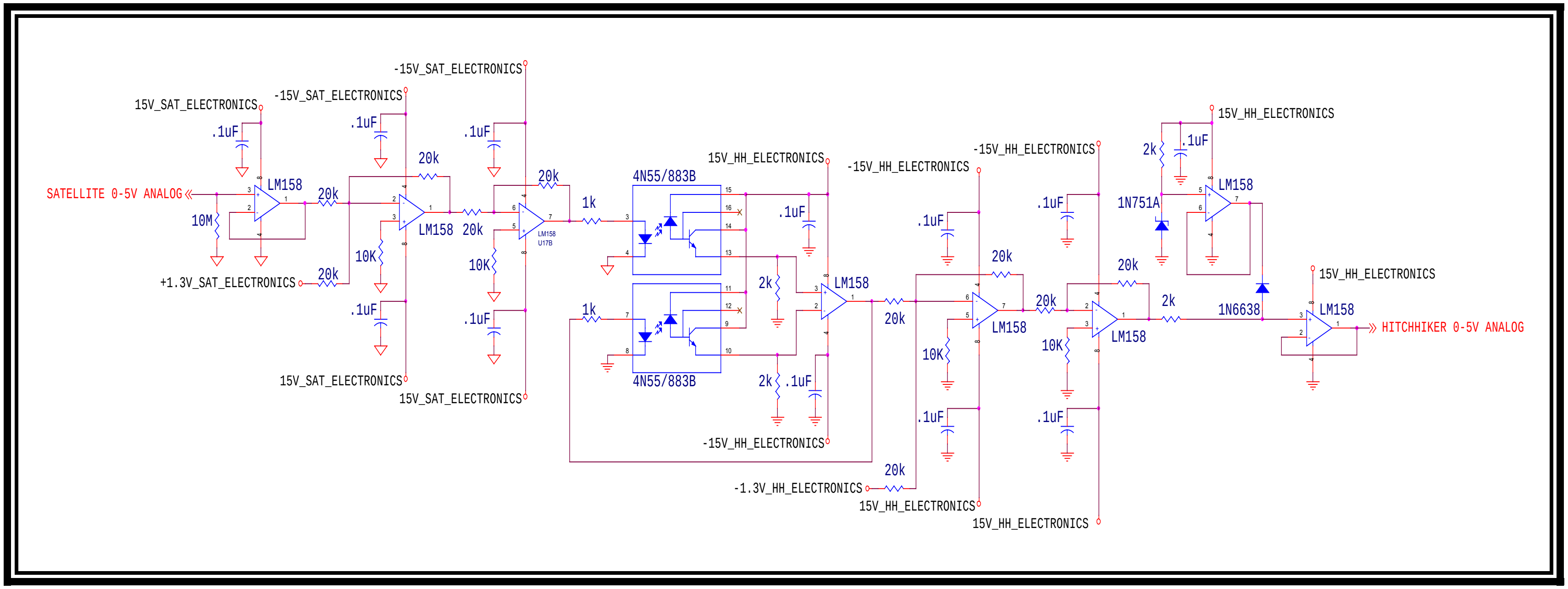


Figure 5-15: MPIB Analog Telemetry Isolation Implementation

6.0 HARDWARE INTEGRATION

6.1 Integration at GSFC

Once the spacecraft developer has completed all activities, the spacecraft is shipped to GSFC for SHELS integration . Environmental controls established during shipment to GSFC are the responsibilities of the spacecraft developer. Upon arrival to GSFC, spacecraft receiving and inspection activities will be performed in accordance with the guidelines established per ISO 9001 requirements. The customer SHELS CPR document will identify all required GSFC activities, as well as the necessary environmental requirements to be established following spacecraft delivery.

As a standard service at GSFC, the SHELS customer can expect clean room environments in the class 100,000 to 300,000 range. If the SHELS customer requires an environment cleaner than class 100,000, special arrangements must be made with Hitchhiker which may result in an optional service cost being passed back to the SHELS customers sponsoring organization. Following post-shipment functional testing and pre-integration electrical check-outs, the SHELS customer satellite is mounted to the ejection plate by GSFC personnel. The integrated satellite and ejection plate assembly is then mounted to the launch structure, which in turn mounts to a mobile dolly for the remaining ground handling activities at GSFC.

Satellite and ejection system electrical check-outs are then performed. The SHELS customer must also support an integrated payload Electro-Magnetic Interference/Electro-Magnetic Compatibility (EMI/EMC) test if the SHELS customer spacecraft uses the umbilical services anytime during the mission. The expected EMI/EMC environment included in this testing is detailed in the Orbiter ICD-2-19001, section 10.7.

There is no requirement that SHELS with an integrated spacecraft be exposed to vibration or thermal vacuum tests. Following completion of all GSFC activities, the SHELS hardware and customer satellite will be wrapped and shipped to KSC via ground transportation, following ISO 9001 compliant practices and procedures.

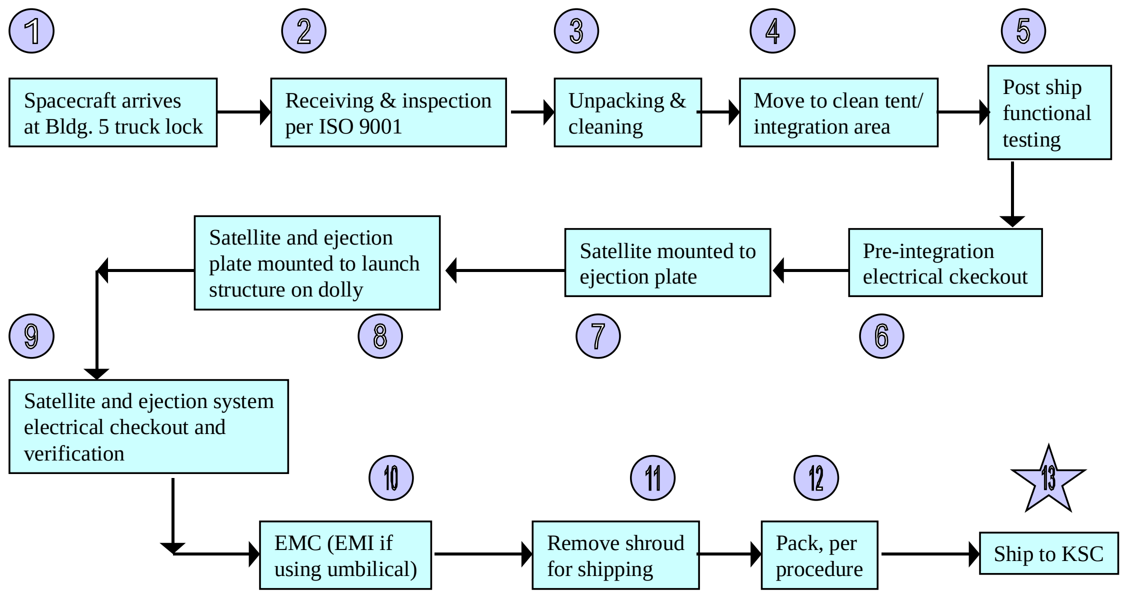


Figure 6-1: SHELS Ground Operation s at GSFC

6.2 Integration at KSC

6.2.1 Integration Overview

Ground processing details and SHELS customer-requested support are documented in the Launch Site Support Annex (LSSA), Annex 8 to the PIP, the Time-critical Ground Handling Requirements (TGHR), and the Operations and Maintenance Requirements Specifications Document (OMRSD). Input to these documents is gathered from the SHELS customer by the Hitchhiker mission manager via the appropriate Ground Operations Working Group (GOWG) meetings, Technical Interchange Meetings (TIM’s), and the CPR. All SHELS customer Technical Operating Procedures (TOP’s) to be performed at Kennedy Space Center (KSC) shall be prepared in accordance with KHB 1700.7B and must be submitted to Hitchhiker two weeks prior to their submittal to KSC. KSC safety requires completion of the review and approval process for hazardous procedures no later than 45 days prior to use.

During launch site processing of the payload, the Shuttle Program will conduct an inspection of the payload for sharp edges, corners, surfaces or protrusions which may damage a crewmember's Extravehicular Activity (EVA) suit or associated equipment. This inspection will be coordinated with the customer and corrective actions will be taken by the customer or the customer's representatives. Hazards not correctable will be identified and documented.

The Shuttle Program will take required photographs of the payload before and after installation in the Orbiter, including closeout photographs to support ground operations, Flight Data File (FDF) development, flightcrew, flight controller training, and for possible in-flight contingencies. These photographic activities will be scheduled and coordinated with the customer.

Training or certification of training will be required for customer personnel performing certain payload ground processing activities. Health reports or physical examinations will also be required for certain operations. Typical activities having these requirements are accessed unescorted to the designated areas.

6.2.2 Customer Processing

The SHELS hardware integrated with the spacecraft will be shipped directly from GSFC to KSC via ground transport. Upon arrival at the launch site, the payload hardware will be delivered to a pre-assigned Payload Processing Facility (PPF). Activities to be performed at the PPF include post-shipment hardware inspection, functional checkout, and preparation for the next phase of integration. The environment of the ground operations facilities at KSC is specified in the Launch Site Accommodations Handbook for Payload, K-STSM-14.1.

Typically, the customer is responsible for the all payload-unique pre-integration activities and utilizes payload-provided GSE. Only highly trained and certified personnel will perform certain payload ground processing activities, such as crane operations and pyrotechnic arming. It is also possible to negotiate launch and landing site technical and personnel support, as well as the use of existing KSC-provided GSE.

6.2.2 Payload Integration

After completion of PPF operations, the payload is transferred to KSC control to begin the ground integration process. The payload will be transported to the Orbiter Processing Facility (OPF) for installation into the Orbiter by a KSC-provided vehicle. Once this activity begins, all operations and testing are scheduled, performed, and controlled by KSC personnel and supported by the customer.   Since HH interfaces have been verified on many previous flights, a Cargo Integration Test Equipment (CITE) test may not be required. The KSC CITE evaluation team will determine (during the development of Annex 8) if CITE testing is required.

Throughout the payload integration process, newly mated or reestablished interfaces are verified. As agreed in Annex 8, space will be provided for the customer to monitor payload parameters using payload-provided GSE. Once testing is completed, any final payload servicing will be performed. The payload is then ready for installation into the Orbiter.

6.2.3 Orbiter Integration

SHELS equipment will arrive as several separate assemblies at the OPF, and will be installed sequentially into the Orbiter. The integrated SHELS casting, satellite and three-sided portion of the thermal shroud will be installed first to the ABA. Following this, the HH control electronics, each mounted on a separate mounting plate, will be installed to the ABA. All interconnect harnesses, including any umbilical cables to the SHELS customer spacecraft, will then be mated, and the payload-to-Orbiter Interface Verification Test (IVT) and closeout procedures will be completed.

If umbilical cabling is required by the SHELS customer spacecraft, then the IVT will consist of verifying that the copper paths within the umbilical have been established. This will entail sending commands and receiving telemetry to and from the spacecraft using SHELS customer supplied GSE. Details of this testing will be defined in the Command and Data Handling Annex, Annex 4 to the PIP, and in the OMRSD.

Following completion of IVT, the front face sheet of the thermal shroud will be installed.
Before the payload bay doors are closed, additional payload-unique servicing may be scheduled on a noninterference basis up until payload bay door closure for OPF rollout. After payload bay door closure, the Orbiter is towed to the VAB for integration with the other Orbiter elements and transported to the pad for launch.

The thermal environment for payloads in the OPF range from 65°F to 85°F, with a nominal set point of 65°F. Requirements outside of this range are negotiated on a case-by-case basis.

6.2.4 Late Payload Operations

If required, payload-unique activities may be performed at the launch pad as required. Typical activities might include top-charge of customer flight batteries, spacecraft and SHELS pyrotechnic circuit arming plug installation, removal of payload protective covers, etc. Details of all late payload operations for SHELS customers will be documented in Annex 8 to the PIP. The thermal environment for payloads at the launch pad range from 45°F to 85°F, with a nominal set point of 65°F. Requirements outside of this range are negotiated on a case-by-case basis.

Reference NSTS 07700, Volume XIV, Appendix 5, for requirements associated with contingencies such as launch delay, scrub turnaround, and launch termination.

6.2.5 Postlanding

After completing the mission, the Orbiter will return to the OPF, where SHELS and other related Airborne Support Equipment (ASE) will be removed from the payload bay and transported to the appropriate PPF for de-integration and returned to the customer. Details of the return of payload ASE to the customer will be documented in Annex 8 to the PIP.

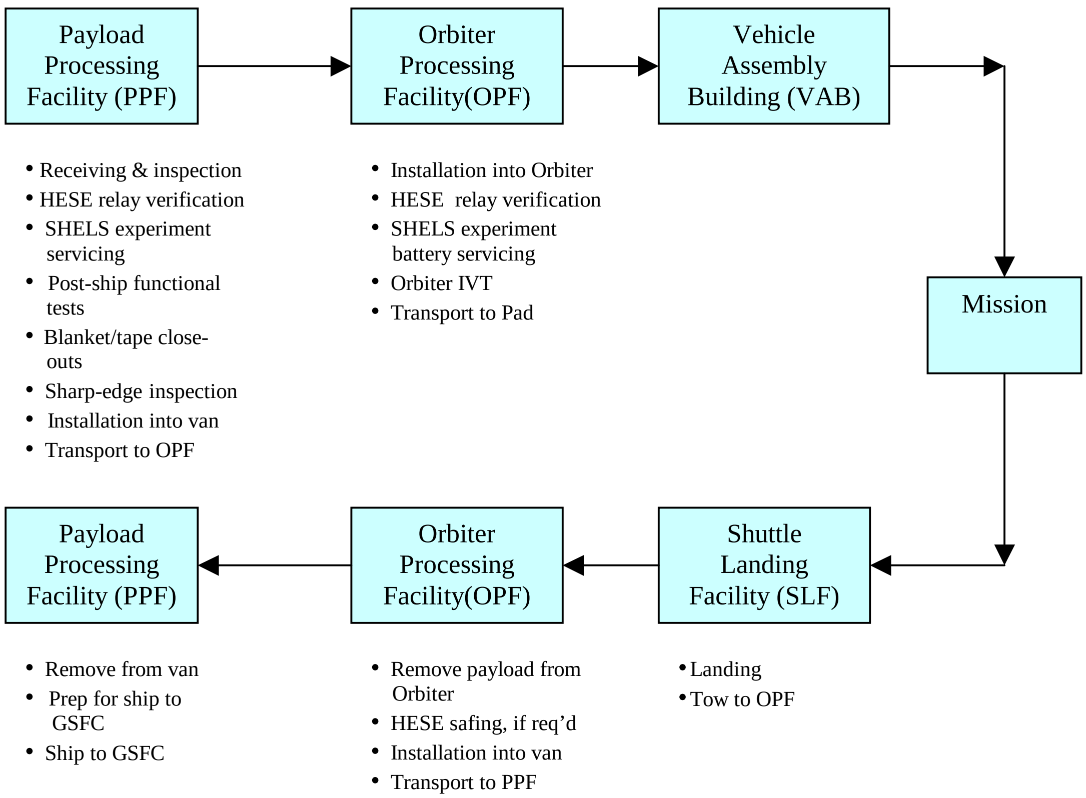


Figure 6-2: SHELS Ground Operations at KSC

APPENDIX A

ACRONYMS AND ABBRIEVIATIONS

ABA	Adapter Beam Assembly
ASPC	Attached Shuttle Payload Center
CARS	Customer Accommodations Requirements Specifications
CG	Center of Gravity
CPR	Customer Payload Requirements
DC	Direct Current
EMC	ElectroMagnetic Compatibility
EMI	ElectroMagnetic Interference
EOM	End Of Mission
EVA	Extravehicular Activity
GAS	Get Away Special
GOWG	Ground Operations Working Group
GSFC	Goddard Space Flight Center
HESE	Hitchhiker Ejection System Electronics
HH	Hitchhiker
HRIU	Hitchhiker Remote Interface Unit
HTS	Hitchhiker Timeline System
ICD	Interface Control Document
IVT	Interface Verification Test
JSC	Johnson Space Center
KSC	Kennedy Space Center
L&L	Launch and Landing
LSSM	Launch Site Support Manager
MET	Mission Elapsed Time
MPIB	Multipurpose Interface Box
NASA	National Aeronautics Space Agency
OMSRD	Orbiter Maintenance System Requirement Document
OPF	Orbiter Processing Facility
OSF	Office of Space Flight
PGSC	Payload and General Support Computer
POCC	Payload Operations Control Center
PPF	Payload Processing Facility
SCA	Shuttle Carrier Aircraft
SHELS	Shuttle Hitchhiker Experiment Launcher System
SIB	Satellite Interface Box
SSP	Standard Switch Panel
SSPPO	Shuttle Small Payload Program Office
STP	Space Test Program
STS	Space Transportation System
SUG	SHELS Users Guide
TIM	Technical Interchange Meeting
TOP	Technical Operating Procedure
V	Volts
VAB	Vehicle Assembly Building
W	Watts